

DOE/MC/29309 -- 4063  
(DE95009709)

## **Piñon Pine Power Project**

**Annual Report  
August 1992 - December 1993**

November 1994

Work Performed Under Contract No.: DE-FC21-92MC29309

For  
U.S. Department of Energy  
Office of Fossil Energy  
Morgantown Energy Technology Center  
Morgantown, West Virginia

By  
Sierra Pacific Power Company  
Reno, Nevada

## **DISCLAIMER**

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, 175 Oak Ridge Turnpike, Oak Ridge, TN 37831; prices available at (615) 576-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161; phone orders accepted at (703) 487-4650.

# **Piñon Pine Power Project**

**Annual Report**  
**August 1992 - December 1993**

Work Performed Under Contract No.: DE-FC21-92MC29309

For  
U.S. Department of Energy  
Office of Fossil Energy  
Morgantown Energy Technology Center  
P.O. Box 880  
Morgantown, West Virginia 26507-0880

By  
Sierra Pacific Power Company  
P.O. Box 10100  
6100 Neil Road  
Reno, Nevada 89520-0400

November 1994

## **ABBREVIATIONS AND ACRONYMS**

<b>CCT</b>	Clean Coal Technology Program
<b>CRADA</b>	Cooperative Research and Development Agreement
<b>DOE</b>	U. S. Department of Energy
<b>EIS</b>	Environmental Impact Statement
<b>EMP</b>	Environmental Monitoring Plan
<b>FW USA</b>	Foster Wheeler USA Corporation
<b>HRSG</b>	Heat Recovery Steam Generator
<b>IGCC</b>	Integrated Gasification Combined-Cycle
<b>KRW</b>	Kellogg-Rust-Westinghouse
<b>LASH</b>	Coal Ash with Spent Limestone
<b>MWK</b>	The M. W. Kellogg Company
<b>NEPA</b>	National Environmental Policy Act
<b>NFPA</b>	National Fire Protection Association
<b>PDU</b>	Process Development Unit
<b>PMP</b>	Project Management Plan
<b>PON</b>	Program Opportunity Notice
<b>PSCN</b>	Public Service Commission of Nevada
<b>PSD</b>	Prevention of Significant Deterioration
<b>SPPCo</b>	Sierra Pacific Power Company
<b>SUFCO</b>	Southern Utah Fuel Company
<b>UEPA</b>	Utility Environmental Protection Act
<b>UPS</b>	Uninterruptible Power Supply

## **TABLE OF CONTENTS**

- 1.0 EXECUTIVE SUMMARY**
- 2.0 INTRODUCTION AND BACKGROUND**
  - 2.1 IGCC TECHNOLOGY OVERVIEW**
  - 2.2 IGCC DEVELOPMENT HISTORY**
  - 2.3 PROJECT SELECTION AND COOPERATIVE AGREEMENT**
  - 2.4 DESCRIPTION OF EXISTING TRACY STATION**
- 3.0 PROJECT OBJECTIVES**
  - 3.1 OVERVIEW OF OBJECTIVES**
  - 3.2 DESCRIPTION OF PROJECT PHASES**
  - 3.3 ACCOMPLISHMENTS**
- 4.0 PLANT DESCRIPTION**
  - 4.1 PIÑON PINE POWER PROJECT**
  - 4.2 GASIFIER ISLAND**
  - 4.3 COMBINED-CYCLE**
  - 4.4 OFFSITES**
- 5.0 SCOPE OF WORK**
  - 5.1 GENERAL PROJECT REQUIREMENTS**
  - 5.2 PROJECT MANAGEMENT**
  - 5.3 ENGINEERING AND DESIGN**
  - 5.4 PROCUREMENT**
  - 5.5 CONSTRUCTION**
  - 5.6 ENVIRONMENTAL PERMITTING AND LICENSING**
  - 5.7 OPERATION**
- 6.0 TECHNICAL IMPACTS ON SCHEDULE**
- 7.0 CONCLUSIONS AND LOOK AHEAD**
- 8.0 APPENDICES**

## **LIST OF FIGURES**

**FIGURE 2.1 TRACY STATION LOCATION**

**FIGURE 2.2 TRACY STATION TOPOGRAPHY**

**FIGURE 2.3 MAP OF EXISTING FACILITIES AT TRACY STATION**

**FIGURE 4.1 MAP OF FACILITIES AT TRACY STATION WITH THE PROPOSED  
ACTION**

## **1.0 EXECUTIVE SUMMARY**

This annual report has been prepared to present the status of the Piñon Pine Power Project, a nominal 104 MWe (gross) integrated gasification combined-cycle (IGCC) power plant addition to Sierra Pacific Power Company's (SPPCo) system. This project will also serve as a demonstration project cost-shared by the U.S. Department of Energy (DOE) and SPPCo under DOE's Clean Coal Technology (CCT) Program. The goal of the CCT Program is to demonstrate advanced coal utilization technologies that are energy efficient and reliable and that are able to achieve substantial reductions in emissions as compared with existing coal technologies.

The Piñon Pine Power Project will demonstrate an IGCC system utilizing the Kellogg-Rust-Westinghouse (KRW) fluidized-bed gasification process operating in an air-blown mode with in-bed desulfurization and hot gas clean-up with a western bituminous coal. The Piñon Pine Power Project will be constructed and operated at SPPCo's Tracy Power Station, an existing power generation facility located on a rural 724-acre plot approximately 17 miles east of Reno, NV (Appendix 1).

SPPCo., the project participant, has contracted with the Foster Wheeler USA Corporation (FW USA) for the overall project management, engineering, procurement and construction of the project. FW USA in turn has subcontracted with The M. W. Kellogg Company (MWK) for the engineering and procurement of key components for the Gasifier Island.

Key accomplishments have been the following:

- Performed testing of zinc based sorbent for desulfurization of the fuel gas. Ash melting point test, coal reactivity tests with the design coal, and fluidization test with coal char were also conducted.
- Completed mapping studies with design coal to develop an operating envelope for the KRW gasifier.
- Executed purchase of GE Frame 6Fa gas turbine generator (GE was only released for engineering).
- Issued heat and material balances and process flow diagrams.

- Completed technical reports for preparation of the Environmental Impact Statement (EIS)
- Completed technical definition for the Class III Estimate.

As a result of the delay in the selection of the combustion turbine as well as the extended environmental activities, progress has been slower than originally planned, with expenditures also limited over the period. Nevertheless, despite the delays encountered, the start of the Demonstration Period (Phase III) is not currently projected to be affected. However, the initial plan to implement a phased construction approach, with installation and operation of the combustion turbine as a peaking unit, will not be implemented because of the installation of approximately 160 MWe of peaking capacity to be operational in mid 1994.

## **2.0 INTRODUCTION AND BACKGROUND**

### **2.1 IGCC Technology Overview**

Coal-fired power plants are still the mainstay of power generation world-wide. The emissions produced by coal combustion have led to an environmental burden to the point where the use of coal as fuel for electricity generation may be threatened. Parallel to the installation of flue gas scrubbers in conventional coal-fired power plants, research is proceeding on innovative power plant concepts which are not only more acceptable from an environmental standpoint but also feature higher efficiency. Technology of this kind is already available for oil and gas fuels in the form of combined cycle gas and steam turbine power plants. To apply combined cycle technology to power production from coal, conversion of coal to a gaseous fuel is required by a coal gasification process. The most common coal gasification process essentially involves partial combustion of coal. This partial combustion provides the energy for further conversion of coal primarily into carbon monoxide and hydrogen.

In many regions in the United States, the effective electric reserves have declined to low levels and it is predicted that there will be a surge in new power plant orders. The criteria used for selecting a power plant technology will have to take into consideration cost competitiveness, environmental superiority, module size, fuel flexibility, reliability and availability, and construction lead time. Based on these criteria, IGCC technology is a leading candidate for new capacity addition. Demonstration of this technology should provide a coal-based option with cost of electricity that is competitive with more conventional technologies.



The Piñon Pine Power Project to be located at SPPCo Tracy Station will incorporate the KRW gasification technology which produces a clean low-Btu gas for use as fuel in a combined cycle power plant for production of low cost electricity in an environmentally sound manner.

The KRW process improves upon first generation IGCC technology in several aspects. Its pressurized, air-blown fluidized bed gasification technology will provide a higher thermal efficiency than a similar oxygen-blown system because it consumes less auxiliary power. A portion of the sulfur pollutants are captured within the fluidized bed before they can exit the gasifier. Additional impurities are removed through an advanced hot gas cleanup system which operates with a regenerative sulfur sorbent to remove sulfur compounds and barrier filters to remove particulates. In addition, the inherent modular design of the system and simple process configuration are expected to yield significantly lower engineering and construction costs.

The Piñon Pine Power Project integrates a number of technologies fostered by DOE. Among these are the KRW Energy Systems fluidized-bed gasifier, in-bed desulfurization using limestone sorbent, and zinc based sorbent sulfur removal from a hot gas stream. DOE and its predecessor agencies have supported development of this fluidized-bed gasification technology since 1972 when the design of a process development unit (PDU) was first initiated under contract with Westinghouse Electric Corporation. Construction of the PDU was completed in 1975 at Westinghouse's Waltz Mill Facility near Madison, Pennsylvania. From 1984 to 1988 the addition of dolomite and limestone to the gasifier bed for in-bed sulfur removal was successfully demonstrated at the PDU. These tests indicated that 85 to 90 percent sulfur removal efficiencies could be routinely achieved while using coal feedstocks containing 2 to 4.5 percent sulfur. In addition, the use of these sorbents in the gasifier was found to increase the product gas heating value while decreasing the production of ammonia, a major contributor to NO<sub>x</sub> emissions.

It is important that a demonstration of the advanced IGCC technology include actual integration of the gasifier with a combined-cycle power plant. This step is necessary in order to evaluate the adequacy of integrated control concepts and to measure actual performance of a complete power generation system on a utility grid. The modular concept of the proposed technology will provide information that is directly applicable to other commercial plants since such plants will essentially incorporate one or more replicates of the demonstration project plant configuration.

## 2.2 IGCC Development History

Almost all of the IGCC demonstration plants were designed around a more conventional approach, i.e., gas produced in the gasifier was either quenched or cooled and scrubbed for low temperature removal of sulfur compounds. These plants also removed ash/slag in a wet state. In order to limit the size of cool down trains and desulfurizer systems, gasifiers for these early plants were oxygen blown, thereby adding to capital cost and parasitic power consumption. Cooling of gas for sulfur removal not only lowered the cycle efficiency, but also required extensive equipment and handling of process water. These plants offered the advantage of reduced number of gasification trains and offered flexibility to adapt them to chemical production.

In order to meet challenges of the market place and environment, a simplified IGCC system incorporating air-blown gasification with hot gas cleanup has been developed. By eliminating the oxygen plant and minimizing the need for gas cooling and wastewater processing equipment, the capital cost is reduced and plant efficiency is improved. Key features of the simplified IGCC system are shown in Appendix 2 and described below:

- **Air-Blown Gasification**







In the simplified IGCC system, about 15 to 20 percent of the gas turbine compressor discharge air is extracted for use as oxidant in the gasifier. A booster air compressor increases the pressure of this extracted air to compensate for pressure losses through the gasifier and downstream hot gas cleanup system and fuel control valve.

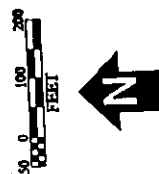
- **Hot Gas Cleanup**

To date, most major gasification plants have utilized cold (wet) cleanup processes. The alternate approach of filtering the gas at high temperature enables the gas to maintain most of the sensible heat resulting in a higher plant efficiency. Equipment is minimized and there is no waste water production. Several types of filtering devices have been tested in pilot facilities and are available from several suppliers.

The site plan illustrates the layout of a proposed power plant. Key features include:

- Water Bodies:** The **Rocky River** flows along the top and left sides, with an **Overflow Parking** area adjacent to it. A large **Cooling Pond** is located at the bottom left.
- Power Generation & Distribution:** The central area contains **Combustion Turbine #3**, **Combustion Turbine #4**, and **Main Transformers**. It also includes **#1 Gas Turbine** and **#2 Gas Turbine** units, along with **Unit #1 & 2 Switchyard** and **Unit #3 Switchyard**.
- Storage & Logistics:** There are several **Gas Tank** and **Oil Tank** storage areas, including **Feed Oil Tank #1** through **Feed Oil Tank #5**. A **Materials Laydown Area** is situated at the top right, and a **New Well** is located near the oil tanks.
- Infrastructure & Support:** The plan shows **Underground Septic Systems**, **Gas Tank**, **Warehouse**, **Machine Shop & Warehouse**, and a **Diesel Fuel Unloading** area. A **Diesel Fire Pump House** is located near the cooling pond.
- Access & Surroundings:** An **Access Road** runs through the site. The **Existing Northern Track Spur** is shown on the right side. A **Grass Berry Adams Pump House** is located near the bottom right corner.

 Existing Structure  
 Existing Road  
 Fenceline  
 Railroad Spur  
 Septic System  
 Under Construction



### **3.0 PROJECT OBJECTIVES**

#### **3.1 Overview of Objectives**

The objectives of the Piñon Pine Power Project are to meet the power needs of the SPPCo customers and to demonstrate the technical, economic and environmental viability of a commercial scale IGCC power plant. This plant is to be based on an air blown, fluidized-bed gasifier incorporating hot gas clean up and a combustion gas turbine capable of utilizing low Btu gas. The project will demonstrate that power plants based on this technology can be built at capital costs and with thermal efficiencies which significantly reduce electric power costs over more conventional technologies. The project will also demonstrate the effectiveness of hot gas clean-up in achieving a negligible environmental impact (reduced SO<sub>2</sub> and NO<sub>x</sub> emissions) and the operation of a low-Btu fuel gas combustion turbine. The performance to be demonstrated will include all major sub-systems of the IGCC system including coal and limestone feed systems, pressurized air-blown fluidized bed gasifier, hot product gas filtering and desulfurization with a regenerative sulfur sorbent, sulfator system, combustion turbine and steam cycle, and integrated control systems. Another objective is to assess the long term reliability, maintainability, and environmental performance of the IGCC technology in a utility setting at a commercial module size.

#### **3.2 Project Phases**

The Piñon Pine Power Project will be divided into the following three distinct phases of activity as shown in the Summary Bar Chart Project Schedule included in Appendix 4:

##### **3.2.1 Phase I - Design**

The objective of activities during this phase is to provide the technical definition and definitive cost of the Piñon Pine Power Project. This effort provides process design, equipment identification and selection, integration of the gasifier system with the power plant, and system test planning as required to make certain that adequate design features exist to assure performance and operational success. Also, all required engineering information and support for all licensing, permitting and reliability activities will be prepared during this phase.

### 3.2.2 Phase II - Construction

This phase includes all activities required to construct the plant in concert with the overall project plan. This will ensure that the facility is procured and constructed to specification, on schedule, and within budget. Procurement activities during this task include purchasing, inspections, expediting, traffic and commercial aspects of in-place subcontracting. Included in this effort are home office construction activities such as safety, quality assurance, labor relations, budgeting and scheduling, and field construction management activities including functions such as supervision of equipment installation, erection of materials, field engineering, field accounting, cost, schedule and material control, and subcontract administration.

### 3.2.3 Phase III - Operation

This phase covers all the labor, materials and services needed for plant operation for a 42-month period. The objective is to provide all the operational and management direction that will be necessary to provide the private sector with technical, economic and environmental evaluations on the advanced coal gasification combined-cycle power plants.

## 3.3 Accomplishments

This section of the report provides a summary of major activities and accomplishments through December 1993.

### 3.3.1 Laboratory Testing

Coal reactivity tests were performed using the thermogravimetric analyzer using char prepared from SUFCO coal and char prepared in presence of limestone. Four tests were done on each of the two samples.

Ash melting points were determined using the hot-stage microscope. Ash samples were prepared with SUFCO coal and SUFCO coal with limestone. Four sets of initial sintering, initial melting and final melting temperatures for the two types of ash were determined.

Fluidization tests were conducted in a 1.375" I.D. cold flow model unit using 22 wt% coal char without limestone and coal char containing 20 wt% calcium oxide at three superficial velocity vs. complete fluidization velocity ratios to establish the magnitude of reduction in fines elutriation due to addition of limestone to the gasifier.

Testing of zinc ferrite and zinc titanate as candidates for the sulfur sorbent in the hot gas clean-up system were conducted under a Cooperative Research and Development Agreement (CRADA) between DOE-METC and MWK. Zinc ferrite displayed a tendency to break up after repeated regenerations. Zinc titanate demonstrated initial encouraging results. However, it also began to display a tendency to decrepitate.

The SPPC/MWK/METC CRADA testing to evaluate the use of Z-SORB III sorbent in desulfurization of the fuel gas from the gasifier was completed. The testing indicated that this sorbent has better mechanical durability than zinc ferrite and zinc titanate sorbents. Although the absorption capacity was observed to decline as the test runs proceeded, the reduction in capacity tended toward stabilizing within acceptable limits when the testing ended. The process design work is proceeding based on utilizing a zinc based sorbent such as Z-SORB III sorbent for fuel gas desulfurization with dry regeneration.

### 3.3.2 Process

Gasifier mapping work was started to develop an operating envelop for the KRW gasifier with SUFCO coal feed and local limestone.

Several computer runs were made with in-house gasifier design programs using the gasifier operating temperature, carbon conversion, fuel gas lower heating value and the gasifier volume as the key variable. All results were plotted and included in the report.

While the mapping work was in progress the laboratory coal reactivity tests confirmed that SUFCO coal relative reactivity was actually slightly better than the proposal value which validated the proposal design.

The initial issue of the process flow diagrams and equipment list were completed and reviewed by the project team. The latest revision of these documents provided the basis for the Class III Cost Estimate.

The Gasifier Island heat and material balances for the Base Operating Case, Maximum Coal Throughput Case and the 60% Turndown Case were completed along with the utility consumption (steam, water, and power) for all three process cases. Heat and material balances for the Base Operating Case are included in Appendix 3.

The plant thermodynamic model was completed based on the Gasifier Island heat and material balances and the gas turbine generator performance data furnished by GE. The steam turbine generator throttle steam pressure and temperature were evaluated. Seven pressure/temperature conditions were studied ranging from 900 psia/900°F to 1500 psig/1000°F. Based on these evaluations, which included estimated equipment costs and turbine generator output, 950 psia/950°F was selected as the throttle pressure/temperature.

An economic analysis of potential cooling methods for the plant was completed. These studies covered systems ranging from the use of cooling pond, cooling pond with supplemental cooling tower, stand-alone cooling tower, spray pond, wet-dry cooling tower and air cooled condenser with auxiliary cooling tower. Based upon these studies, including the preparation of order of magnitude estimates, the selection of a conventional cooling tower utilizing a closed loop cooling water system and surface condenser was recommended.

### 3.3.3 Engineering

The technical definition for the Class III Estimate was developed including alternative arrangements for cost reduction options. This estimate will update the project costs to reflect the gas turbine generator selected for the project along with size changes of associated plant facilities.

The purchase contract for the GE Frame 6Fa gas turbine generator was executed. However, GE was released to proceed with engineering only. GE drawings transmittals are underway commencing with performance runs to define the gas turbine operating envelope (i.e., determining the effects of variations in ambient air temperature, load, fuel composition, fuel temperature, air extraction rate and other factors).

Preparation of the project job specifications is underway. These specifications are being prepared by FW USA and reviewed by MWK and SPPCo to maximize consistency in plant design and construction.

The requisition and specifications for the site survey and geotechnical investigation subcontract were completed and issued for inquiry.

#### 3.3.4 Environmental/Permitting Activities

SPPCo and its contractors, Ebasco and ENSR, have provided DOE technical reports in support of DOE's preparation of the EIS. These reports covered the following subjects:

- Air Quality
- Water Resources
- Solid & Hazardous Wastes
- Cultural Resources
- Socioeconomics
- Biological Resources
- Health, Safety and Noise
- Geology, Soils and Seismicity
- Visual Resources

Also prepared in this effort was a technical description of the plant prepared by FW USA and MWK. These technical reports were provided in sufficient detail to enable the DOE and its contractors to prepare the EIS.

SPPCo also completed its Prevention of Significant Deterioration (PSD) permit application and filed it with the State of Nevada. It is complete with the exception of the incorporation of additional meteorological data currently being gathered at the Tracy Plant site.

SPPCo has completed the presentation of its 1993 Electric Resource Plan to the Public Service Commission of Nevada (PSCN). The PSCN issued an Interim Opinion and Order giving SPPCo approval to proceed with the Piñon Pine Project.



## **4.0 PLANT DESCRIPTION**

The major systems of the Piñon Pine Power Project IGCC facility are described in this section. Process flow diagrams for these systems are included in the Appendices 3.

### **4.1 Piñon Pine Power Project**

The proposed Piñon Pine Power Project would demonstrate the performance of a coal-based Integrated Gasification Combined Cycle (IGCC) power plant. The proposed facility is illustrated in figure 4-1. The IGCC power plant would include a gasifier island (based on KRW's pressurized, air-blown, fluidized-bed coal gasifier, coupled to a combustion turbine and steam-based power island. The gasifier island would include a pneumatic coal feed system, fed by lockhoppers, which would introduce the coal into the gasifier; and an air-blown KRW gasifier capable of producing low-BTU gas. The gas from the gasifier would be transferred to a hot gas conditioning system for removal of sulfur compounds, particulates, and other contaminants as necessary to meet environmental and combustion turbine fuel requirements. The power island would include a combustion turbine (approximately 61 MW gross) capable of using natural gas, coal gas, or propane; a heat recovery steam generator (HRSG) system capable of supplying superheated high pressure steam generated in the HRSG and the gasification and desulfurization sections; a steam turbine (approximately 43 MW gross); all control systems; and required auxiliary systems.

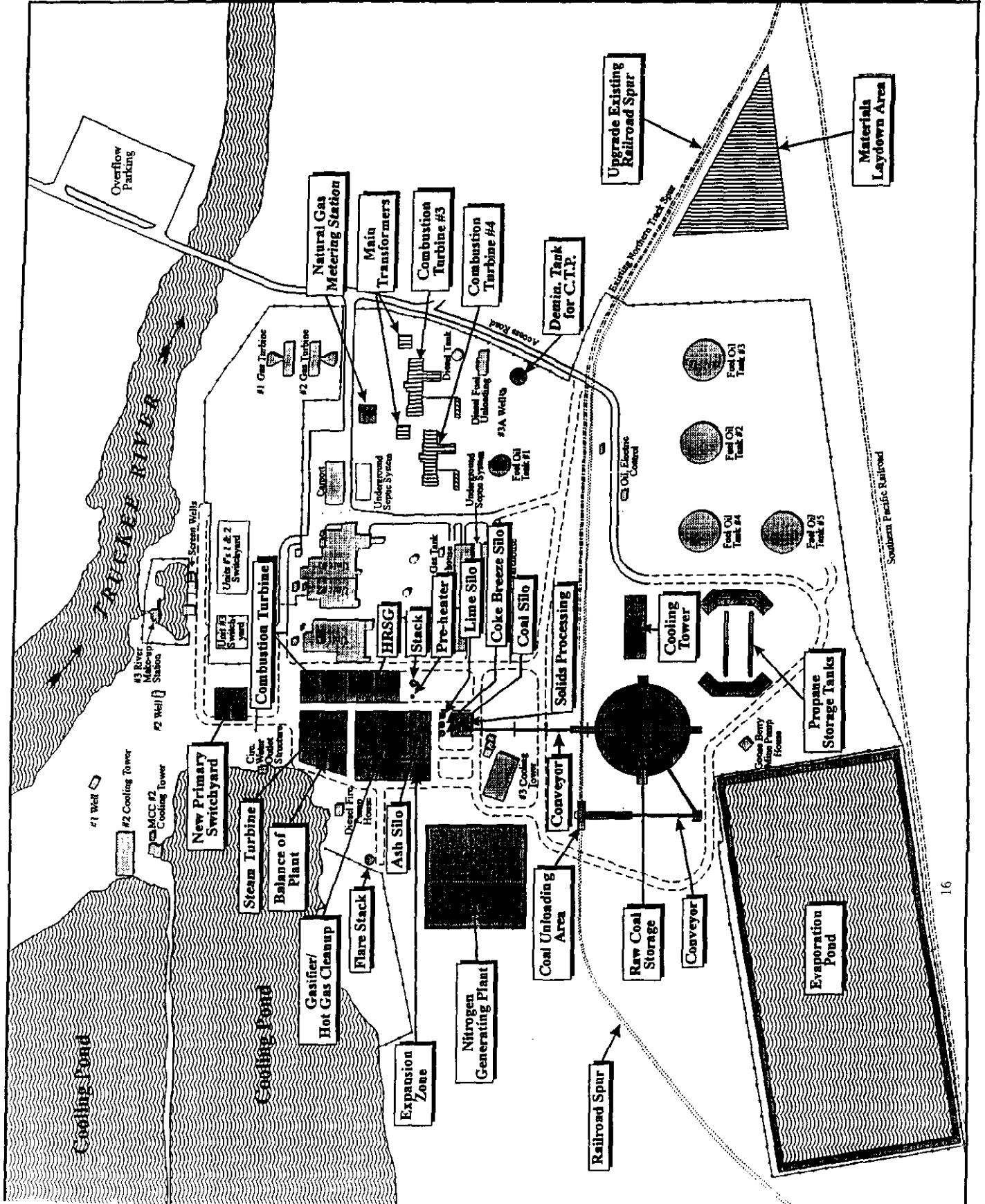
Key equipment items and systems, which would be part of the unique technology of the proposed Piñon Pine Power Project include the KRW gasifier with in-bed desulfurization, external regenerable sulfur removal, fine particulate filters, and some aspects of the gas turbine generator. Advanced KRW gasification technology produces a low-BTU gas, which is used as fuel in a combined-cycle power plant, and includes hot gas removal of particulates and sulfur compounds from the fuel gas, resulting in lower atmospheric emissions. Desulfurization would be accomplished by a combination of limestone fed to the gasifier and treatment of the gas in external desulfurization vessels using a zinc-based sulfur sorbent. Particulates would be removed by one or more high-efficiency cyclones and a barrier filter. These operations would be carried out at an elevated temperature to eliminate the inefficiency of a capital cost for cooling and cleaning the gas at low temperature, which is associated with other IGCC systems. Since water vapor is not condensed in the hot gas clean-up process, water effluents would be reduced and would consist only of a feedwater treating system effluent and boiler and cooling tower blowdown.

Figure 4.1 Map of facilities at Tracy Station with the proposed action.

# Legend

- Existing Structure
- Existing Road
- Fenceline
- Railroad Spur
- Septic System
- Under Construction
- Proposed Structure
- Proposed Road
- Proposed Railroad Spur

50 0 100 200  
FEET



Raw coal, from western States, would be received at the plant from a unit train consisting of approximately 84 railcars of between 100- and 110-ton capacity, arriving approximately once a week. Currently, Southern Pacific Railroad facilities are on site; the railroad line is a main east-west supply route. Upgrading and extending the spur on SPPCo. land would be required for the proposed project.

Coal would be received at an enclosed unloading station and transferred to a coal storage dome. The unloading station would consist of two receiving hoppers, each equipped with a vibrating-type unloading feeder that would feed the raw coal conveyor systems. All material handling systems would be enclosed and supplied with dust collection systems for environmental control. Dust control equipment would be permitted as required by State and Federal regulations.

#### **4.2 Gasifier Island**

Coal and limestone (as well as coke breeze during start-up) are fed from a single conveyor to the atmospheric feed surge bin. This bin periodically discharges solids into feed pressurization lockhoppers from where coal and limestone are fed to the gasifier on a continuous basis by a rotary coal feeder.

Solids from the feeder are picked up by transport air and fed directly to the gasifier central feed tube. Additional heated air from the recuperator is also fed through the same feed tube and the streams merge to form a central jet where the coal is quickly devolatilized, with the remaining char and limestone entering the bed. Extraction steam from the steam turbine and recycle gas are also fed to the gasifier bed to serve as reactant and bed fluidization media. Carbon monoxide and hydrogen form the major combustible constituents of the product gas.

Air for the gasifier island is extracted from the gas turbine air compressor. A portion of this air is diverted for use in start-up or to furnish the air required for regeneration of the zinc based desulfurization sorbent. The major portion of the air is cooled and compressed to above gasifier operating pressure. The air exiting the boost air compressor is reheated in the air recuperator and fed to the gasifier. A portion of this compressed air is cooled for use as coal transport air to feed solids into the gasifier and another stream is further compressed to serve as pressurization gas for the feed lockhopper system.

Gasification also results in the release of sulfur from the coal, primarily in the form of hydrogen sulfide some of which is absorbed by calcined limestone in the gasifier bed to form calcium sulfide. This calcium sulfide is withdrawn with coal

ash and unconverted char via the gasifier annulus which is fluidized and cooled by a stream of recycle gas. The spent solids leaving the gasifier are transferred via the ash feeder to the ash lockhopper system for collection and delivery to the sulfator.

The product gas exiting the top of the gasifier contains a significant quantity of entrained solids. The product gas passes through the gasifier cyclone which removes most of the solids and returns these to the gasifier bed. Gas from the cyclone is directed to the product gas coolers for heat recovery and steam generation.

Product gas from the gas coolers is sent to the hot gas filter which removes essentially all of the remaining particulates. The particulate free gas from the hot gas filter is sent to the desulfurization system for removal of sulfur compounds. Sulfur compounds are reduced in the gas by a zinc based sorbent. The desulfurization system consists of two vessels each having a packed bed of the sorbent. One bed operates in a sulfidation mode while the second bed is either being regenerated or is on standby. A hot diluted air stream is utilized for sorbent regeneration. The sulfur dioxide rich gas from regeneration is sent to the sulfator for sulfur dioxide capture.

A stream of gas exiting the desulfurizer system is cooled for use as recycle gas. A portion of the cooled recycle gas is used for solids transport in the sulfator system. The major quantity of recycle gas is compressed for use as gasifier fluidization gas, filter blowback gas, and ash and filter lockhopper system pressurization gas.

The clean fuel gas exiting the desulfurization system is passed through the guard cyclone to capture any solids in the gas stream and collects them in the solids drum. Normally, it is expected that gas will be free of solids, however, the guard drum is added as a protective device for the gas turbine.

Fines removed by the filter elements are collected in the bottom of the filter vessel, cooled and discharged through the filter fines lockhopper system.

Vent gas from the ash and the filter fines lockhopper is routed to the sulfator.

With the exception of a small quantity of sulfur in the fuel gas to the gas turbine, all of the sulfur in coal is ultimately disposed of in the sulfator system. In addition to oxidation of calcium sulfide produced in the gasifier to calcium sulfate, the sulfator system also combusts residual char in the ash and fines collected from

gasification and captures sulfur dioxide from both the residual char combustion and the desulfurizer regeneration effluent gas. Also, a small recycle gas stream (transport and pressurization gas) is combusted in the sulfator. All of these reactions are highly exothermic.

The sulfator is a bubbling bed reactor which is fluidized by air supplied by the sulfator air compressor. Solids exiting the gasifier bottom are conveyed from the ash lockhopper system to the sulfator with cooled recycle gas. Fresh limestone, from the limestone feed hopper is fed by using instrument air to pressurize it into the sulfator during normal operation. The sulfator bed temperature is controlled by generating saturated steam in the primary solids cooler.

Filter fines from the lockhopper system are conveyed by a stream of recycle gas to the fines combustor to burn off carbon for additional heat recovery.

Flue gas leaving the sulfator passes through the sulfator cyclone and is then mixed with flue gas from the fines combustors prior to cooling in the heat recovery steam generator. Gas cooling is accomplished by generation of high pressure steam and preheating of boiler feedwater. All of the steam generated in the gasifier island is slightly superheated prior to export to the power island. The flue gas then passes through the sulfator flue gas bag house filter and is sent to the stack.

Solids leaving the bottom of the sulfator are cooled in the sulfator solids screw cooler, withdrawn through a lockhopper system and are discharged on to a conveyor for storage and disposal by truck.

#### **4.3 Combined-Cycle**

A General Electric Model MS6001FA Gas Turbine Engine (70.1 MW ISO rating) has been selected as the prime mover for the Piñon Pine Power Plant. It is an industrial frame-type gas turbine, scaled-down from GE's MS7001FA (150 MW) model. The technologically advanced firing temperature and cooling system of F-class gas turbines provide such units operating in combined cycle power plants with the highest total-cycle efficiency of any proven type of fossil-fueled electric power generation system. The engine's output shaft power will be reduced in rotative speed in a gearbox, from the optimum-efficiency value for a gas turbine of this size. Mechanical power will then be converted to electrical power in a once-through air-cooled synchronous generator.

Available thermal power in the exhaust gases will be captured in a heat recovery steam generator (HRSG) to drive a condensing steam turbine generator.

The HRSG generates steam at three pressure levels. Steam generated in the HRSG and high pressure steam generated in the Gasifier Island, are combined, superheated in the HRSG and sent to the steam turbine generator. Low pressure steam generated is sent to the steam turbine generator and provides peaking steam for the deaerator heater.

The steam turbine generator is a condensing type. Extractions provide steam, after letdown and desuperheating, to the gasifier. Throttle steam letdown is used if and when low throttle steam rates cause the extraction pressure to fall unacceptably low. Additionally, this extraction will provide steam for injection at the gas turbine generator for  $\text{NO}_x$  control when operating on natural gas or propane fuel.

The steam turbine has an additional extraction providing steam to the boiler feedwater preheater.

The steam turbine exhausts into a surface condenser. Cooling water is used to condense the exhaust steam. Condensate is pumped from the condenser by the hotwell condensate pumps through the boiler feed water preheater for the recovery of low level heat and thence to the deaerator. Venting of the condenser is accomplished by a vacuum pump system.

High pressure boiler feed water is pumped from the deaerator to the evaporator and Gasifier Island by the high pressure boiler feedwater pumps. High pressure boiler feedwater to the high pressure evaporator is preheated in an economizer section of the HRSG. Deaerated low pressure boiler feed water is pumped to the low pressure evaporators by the low pressure boiler feed water pumps. Boiler feedwater is preheated in an economizer section of the HRSG.

#### **4.4 Offsites**

Raw coal, size 2" x 0, is received at the plant from a unit train consisting of up to eighty-four 100 ton railcars approximately every seven days. The coal is received at the enclosed unloading station and transferred to the coal storage dome. The unloading station will be enclosed and provided with a dust collection system to avoid uncontrolled coal dust emissions. The unloading station consists of two receiving hoppers, each equipped with belt type unloading feeder which feed the

raw coal conveyor system. The conveyor system consists of the raw coal transfer conveyor and raw coal elevating conveyor. All material handling systems will be supplied with dust collection systems for environmental control, with special attention being paid to dust generating areas such as transfer points. Coal is weighed in transit by the raw coal receiving scale located on the raw coal transfer conveyor. An automatic sampling system is located at the discharge of the raw coal transfer conveyor which collects a representative sample to determine the quality of coal received. The raw coal unloading and conveyor system is sized to handle an 84 railcar train unloading operation in a four-hour period.

The coal is stored in a large field erected storage dome which will be sized to store over 16,000 tons of coal, or approximately twenty day's requirement. No exposed storage of coal, such as a coal pile, is planned, thus all coal storage will be within the dome.

Coal in the storage dome is reclaimed by the automated coal pile reclaimer or discharged by emergency pile dischargers and vibratory feeders onto the raw coal collecting conveyor. This conveyor transfers the coal to the crushing station for crushing and screening.

In coal crushing and screening, the raw coal passes through a magnetic separator and is fed to the hammer mill to reduce the material size from 2' x 0" to 1/4" x 0". The vibrating screen with 1/4" square holes under the crusher will control the product top size. Oversize material will return to the mill for further reduction through the bucket elevator. The product-size material is conveyed away by a high angle conveyor and deposited in the coal silo. The coal silo is sized for 24-hour feed to the gasifier.

Two parallel systems of gasifier feed conveying equipment are provided from the coal silo to the gasifier area. Each line of the conveying system consists of a weigh belt feeder, a gathering conveyor and an elevating conveyor. One system will be operating continuously while the other will be a standby spare. Each conveying line can be utilized to handle coal, limestone and coke. As with the raw coal handling system, care will be taken to control any dust emission sources by means of dust collection system.

Dried coke breeze, 1/4" x 0, is received in the plant via trucks with pneumatic trailers for initial plant start-up and for each subsequent gasifier start-up. The sized coke is conveyed pneumatically to an 800 ton capacity coke storage silo using the truck-trailer pneumatic blower. Exhaust air from the filling operation

will be vented through a dust control filter system. The material from the coke silo is conveyed to the gasifier utilizing one of the coal conveyor systems. The coke silo will be equipped with a weigh feeder to feed the said coal conveyor system.

Sized limestone is received in the plant via trucks with pneumatic trailers on a daily basis. The sized limestone is conveyed pneumatically to a 300 ton (5-day) capacity limestone storage silo using the truck trailer pneumatic blower. Exhaust air from this filling operation will also be vented through a dust control filter system. The material from the limestone silo is then fed at a controlled rate by a weigh feeder and blended with the coal on the same conveying line feeding the gasifier. Provisions are also included to transport limestone to the sulfator limestone feed hopper by pneumatic conveying. The material is discharged from the limestone silo and fed to the pneumatic conveying line by rotary airlock feeder. Two redundant systems are provided with one operating and the other as standby spare.

Dust collection systems will be provided in the plant for proper environmental control. Fabric filter collectors will be used to control fugitive dust emissions from the transport and transfer of coal, coke and limestone.

Wastewater from the demineralization package and cooling tower blowdown will be discharged to the wastewater collection system. The wastewater system will discharge to a wastewater sump. The wastewater sump pumps will pump this effluent to the evaporation pond.

The pond will be double lined and the system will be designed to meet the requirements of the Nevada Division of Environmental Protection. The pond surface area (approx. 10 acres) is minimized by the use of floating water spray units. These are located across the pond surface, each equipped with its own electric drive system. Water is pumped up through each unit and sprayed across the pond surface improving the evaporation rate. The wastewater is not anticipated to result in any adverse effect on wildlife such as migrating water fowl. Monofilament line with 25' spacing has been used by SPPCo to successfully discourage migrating water fowl from landing in several of SPPCo's facilities and is unobtrusive to the human observer.



Cooled solid waste (LASH) consisting of ash, fines and sulfated limestone from the sulfation unit is conveyed continuously to the solid waste storage silo using a belt conveyor system. The air displaced from the silo and the conveyor is vented through the bin filter.

The LASH in the silo is loaded-out onto trucks during the day shift operation, 5 days per week. The silo is equipped with a bin discharger, discharge valve and a telescopic loading chute with a bag filter and fan to minimize dusting during the truck loading operation. The LASH is then hauled to the final disposal point. A local landfill has expressed interest in using the material as a cover, and other usages are being investigated.

The solid waste silo is sized for three days of storage (400 tons) to handle the solid waste production over the weekend without the need of the truck load-out operation.

The raw water system provides water to the demineralization package which in turn provides boiler feedwater makeup to the deaerator. Additionally the raw water system provides water for the plant utility water system for miscellaneous users such as service wash stations. Well water is the source of water for the plant raw water system. Well water is pumped to the existing Unit 3 raw water tank and then pumped by the raw water pumps to the plant raw water system.

River water provides makeup water for the cooling tower. Raw water is pumped from the existing river water intake to the cooling tower basin by the river water pumps.

Water for safety showers and eyewashes will be provided by the existing plant system. Drinking water is provided as a brought-in bottled source.

Fire protection water will be provided by the existing plant system to the fire protection water loop. The source of fire protection water is the existing cooling pond. Three fire protection water pumps are presently installed together with a jockey pump.

Makeup boiler feedwater is demineralized by a package consisting of cation, degasification, anion and mixed bed units. Also included are the storage and feeding of regenerating caustic and sulfuric acid, and appropriate local controls, including neutralization controls. Spare acid and caustic pumps and the neutralization air mixing system are also included.

Regeneration waste is stored in a neutralization tank, where the waste is mixed and neutralized before it is sent to the dirty water sewer. Acid and caustic pumps are provided for neutralization.

Demineralized water is stored in a storage tank and pumped to the condensate system by the demineralized water pumps.

A chemical injection package consisting of facilities to feed and control appropriate quantities of oxygen scavengers, scale and corrosion inhibitors, and filming and neutralizing agents to the appropriate locations within the boiler feedwater system is provided.

A conventional induced-draft counter-flow cooling tower will be used for the plant cooling water system. The basin is below grade. Cooling water is circulated by the vertical turbine cooling water pumps.

The cooling tower is designed for the 2½% occurrence condition of a 61°F wet bulb temperature and provides 71°F cooling water at that condition. Blowdown from the system will be sent to the evaporation pond.

Biocide injection is provided by a biocide feeder. Other additives, corrosion inhibitors, pH control biocides, and scale/deposit inhibitors, are injected into the cooling water by the water treatment injection system.

A conventional plant and instrument air compression system is provided. Two air compressors, one operating, one spare, are provided for the system. A single air receiver provides adequate surge capacity. The air is dried to a -40°F dewpoint using an air drying desiccant system prior to branching off to plant and instrument air headers.

A flare system is provided to incinerate the full product gas flow from the gasifier in the event of a power plant outage, gasifier start-up, or other emergencies. The flare is a vertical free-standing system. Pilots will be designed to use natural gas or propane.

Propane is planned as a tertiary emergency fuel to the combustion gas turbine. Liquid propane will be delivered by tank truck or tank car and stored in two 100,000 gallon (nominal) storage drums. The drums will be oriented, and earthen berms constructed, to minimize damage in the event of tank failure. Storage will be in accordance with the applicable NFPA requirements. When required, liquid

propane is drawn off the storage drums and pumped to the vaporizer prior to combustion as fuel in the combustion gas turbine.

Nitrogen is required by the process for regeneration of the sulfur absorbing sorbent, maintaining a constant flow of purge gas through selected equipment and instruments, blow back cleaning of the hot gas filter (when normal process gas is unavailable), pneumatic conveying of coal dust and system purging at shutdown.

The nitrogen package is a cryogenic air separation plant wherein the constituents of air are separated by cryogenic distillation delivering high purity nitrogen in the required quantity. Components of the package include compressors, storage tanks, a liquid nitrogen pump and vaporizers sized to provide for start-up, normal operation and a safe shutdown of the facility.

The existing Tracy sub-station is supplied at 120 KV. Connection to this system will be through tie and service breakers feeding unit transformers connected to the gas and steam turbo-generators. The generators will be rated at 13.8 KV with maximum generator output equal to elevated temperature and/or auxiliary cooling transformer rating as required. The auxiliary power will be fed from each generator transformer servicing large motors 250 hp and over at 4.16 KV and 480 V for general distribution. The 4.16 KV and 480 V will be radial distribution. A second feeder from an existing 4.16KV transformer will permit alternate service in the event of maintenance turnarounds or equipment outages. However, this transformer will not be able to carry the coal gasification process in addition to the generator auxiliaries.

Auxiliary systems within the plant will be provided through UPS or DC Batteries to support personnel safety and critical equipment during shutdowns or power outages where required.

## **5.0 SCOPE OF WORK**

### **5.1 General Project Requirements**

The objective of this project is to demonstrate IGCC at a large scale for use in commercial electric generating plants. The project is to demonstrate equipment and system operability, performance and reliability, as well as process performance in removing sulfur dioxide and minimizing the formation of oxides of nitrogen. The specific goal of the project is to demonstrate that the air-blown IGCC technology is a cost effective, reliable, more efficient and environmentally superior

alternative to conventional coal-fired electric power generation with flue gas desulfurization.

The project is aimed at demonstrating IGCC technology in a plant that is to be integrated into the SPPCo system. SPPCo proposes to design, construct and operate a grass-roots, integrated coal gasification combined-cycle facility at its Tracy Station near Reno, Nevada.

In this application of the process, one KRW gasifier, operating in the air blown mode with in-bed desulfurization and hot gas cleanup technology, will convert approximately 800 tons per day of bituminous coal into a low BTU fuel gas for use in a combustion turbine generator. The exhaust gases from the turbine will generate steam in an HRSG to drive a steam turbine generator. The plant will produce a nominal 95 MWe (net) of total electric power.

## **5.2 Project Management**

The project will be centrally managed by the Project Director of SPPCo. All management, reporting, and project reviews for the project shall be as required by the Cooperative Agreement. The Project Director shall be the official point of contact between SPPCo and DOE for the execution of the Cooperative Agreement. The Project Director shall be responsible for assuring that the project is conducted in accordance with the cost, schedule and technical baseline established in the Project Management Plant (PMP) and subsequent updates.

SPPCo has entered into the management and execution of a contract with FW USA for design and construction of the facility. MWK will be a subcontractor to FW USA for the design of the KRW fluidized bed gasification process.

Implementation details for all tasks shall be provided in a detailed schedule and Work Breakdown Schedule for the overall project presented in the PMP. An outline matrix of planned tests and procedures for the operational phase of the project shall be included to ensure that the basic design and installation philosophy match required operating and testing philosophies. The PMP shall be updated during each budget period of the project to reflect changes to the project baseline.

The Project Team under the direction of the Project Director will be responsible for coordination, monitoring and reporting requirements in accordance with the Cooperative Agreement.

### **5.3 Engineering and Design**

This effort provides process design, equipment identification and selection, integration of the gasifier system with the power plant, and system test planning as required to make certain that adequate design features exist to assure performance and operational success. The engineering and design effort is split into three separate tasks:

#### **5.3.1 Gasifier Island**

The areas of the plant addressed under this task include:

Area 200	Oxidant Compression and Supply
Area 300	Coal Gasification
Area 400	Gas Stream Heat Recovery
Area 500	Gas Stream Particulate Removal
Area 600	Desulfurization
Area 900	Recycle Gas Compression

##### **a. Process Design**

Work under this task will provide a process specification package with supporting details for the gasification portion of the plant and plans for the integration of MWK's KRW gasification technology with the combined-cycle power plant. This effort will include, but not be limited to:

- Equipment Arrangement/Process Description
- Material and Energy Balances/Process Flow Diagrams
- Start-Up, Shutdown and Normal Operating Conditions
- Operating Philosophy/Test Plans
- Control Philosophy/Test Plans
- Supporting Technical Data/Process Loadsheets
- Special Design Requirements
- Catalyst and Chemical Requirements

b. Preliminary Engineering

Information to be generated under this task will include, but is not limited to, materials of construction, vessel analytical sketches, equipment design specifications, equipment summary sheets, process control diagrams, furnace data, exchanger data, plot plans, planning layout drawings, piping and instrument diagrams, requests for quotation, selection of equipment design and vendors, equipment general arrangement and elevation drawings, requisitions for certain instrumentation and piping items, piping flexibility/support studies of major lines, preliminary instrumentation and electrical runs, instrumentation power requirements, material take-off and requisition of alloy piping, and vendor utility requirements.

c. Detailed Engineering

This task will focus on the production phase of the project including the detailed design work and bulk material requisitions required prior to construction as well as the requisite coordination work during the construction phase for the following areas:

- Piping
- Structural
- Concrete
- Buildings
- Electrical
- Instrumentation
- Insulation

5.3.2 Combined-Cycle

The areas of the plant addressed under this task are:

Area 700	Gas Turbine Generator
Area 800	Steam Turbine Generator and Heat Recovery Steam Generator

This effort will proceed under three tasks mirroring that of the gasification and offsites activity.

a. **Process Design**

The primary effort involved during this task will be to establish requirements for the interfacing enumerated below:

- Low-Btu Fuel Gas Requirements
- Auxiliary Natural Gas Requirements
- Extraction Air Limitations
- Boiler Feedwater Requirements
- Cooling Water Requirements
- Steam System Integration
- Feedwater and Condensate Integration
- Electrical Power, Generated and Auxiliary, Integration
- Control and Operating Philosophy and Systems
- Facilities Requirements

This task shall include an evaluation of the combustion properties of the low-Btu fuel, establishment of the combustor design requirements, preliminary design of the valving and fuel delivery system, and an analysis of the overall plant control system and operating procedures.

b. **Preliminary Engineering**

This task shall entail development of all the analytical and design planning work to refine the design details of the combined-cycle plant sections. Selection of vendors for various subcontracted equipment items, notably the heat recovery steam generator, will be made. Other efforts will include final block diagrams, preparation of piping and instrumentation drawings, equipment specifications, plot plans, utility requirements, planning layout drawings, piping flexibility analyses, and instrumentation and electrical drawings.

c. **Detailed Engineering**

This task will focus on the production phase of the project including detailed design work, bulk material requisitions and procurement for materials. The work will encompass piping drawings with bill of materials, electrical and conduit drawings, building and foundation

drawings, instrument drawings, insulation details and all other necessary construction drawings.

### 5.3.3 Offsites

The areas of plant addressed under this task include:

Area 100	Solids Receiving, Drying and Grinding
Area 1000	Wastewater Treatment
Area 1100	Solid Waste Handling
Area 1200	Balance of Plant

The engineering effort for these areas will proceed in parallel with that of the gasification and combined-cycle efforts.

#### a. Process Design

*Primary emphasis will be centered on establishing requirement for the areas noted above as they interface with the gasification and combined-cycle systems including the following:*

- Utility flow diagrams and descriptions, motor list, coal receipt and handling flow diagrams and descriptions, equipment lists, steam and water balances, effluent summaries, preliminary building requirement and site preparation requirements.

#### b. Preliminary Engineering

This task involves analytical and planning phase work for the offsites areas described above. Aspects of the two include development of the following:

- Plot plan, plant road drawings, utility block flow diagram, utility detailed description, coal receipt and handling detailed descriptions, waste treatment descriptions, piping & instrumentation diagrams, materials of construction, vessel analytical sketches and mechanical drawings, equipment summary sheets, exchanger data, selection of packaged system and equipment vendors, requisitions of some instruments and piping items, electrical one line diagrams, planning layout



drawings, instruments and electrical runs, instrument power requirements, material take-offs and requisition of alloy piping.

c. **Detailed Engineering**

This task will focus on the production phase of the project including detailed design work and bulk material requisitioning needed to start construction, together with the coordination required to be performed during the construction phase. The work includes the following:

- Preparation of piping, structural steel, concrete, electrical, instrumentation, building and insulation drawings, details and requisitions.

**5.4 Procurement Services**

This task includes the activities required to develop vendor and subcontractor lists, issue inquiries, and select vendors for the equipment and materials. This task does not include the purchase of equipment and materials, however vendor engineering services shall be procured where these are required to ensure that the Phase I definitive estimate is of adequate quality, and to advance the design effort. This task is divided into two areas:

a. **Procure Vendor Engineering Services**

Procure the engineering services from vendor for key equipment items to assist in estimating and design activities. Key equipment items will include, but are not limited to:

- Gas Turbine Generator
- Heat Recovery Steam Generator
- Steam Turbine Generator

b. **Inquire and Select Balance of Equipment and Construction Subcontracts**

The balance of the equipment and the construction subcontracts will be inquired, the bids will be analyzed, and the vendors/subcontractors selected

in preparation for the purchase orders/subcontracts which are placed in Phase II.

## **5.5 Construction & Start-Up**

### **5.5.1 Construction**

This task includes all activities required to construct the plant in concert with the overall project plan. This will ensure that the facility is procured and constructed to specification, on schedule, and within budget. Procurement activities during this task include purchasing, inspection, expediting, traffic and commercial aspects of in-place subcontracting. Included in this effort are home office construction activities such as safety, quality assurance, labor relations, budgeting and scheduling, and field construction management activities including functions such as supervision of equipment installation, erection of materials, field engineering, field accounting, cost, schedule and material control, and subcontract administration. This task will include, but not be limited to:

- Issue purchase orders and subcontracts to the vendors/subcontractors. Work includes expediting, inspecting, and coordinating traffic for the equipment.
- The work effort during this task includes development of a construction execution plan, detailed schedule, qualified bidder's list, site survey, tool and equipment lists, field administration procedures, material control procedures, safety procedures and reports, construction engineering reports, quality assurance plans and procedures, welding engineering reports, scheduling reports and construction progress reports.
- The work effort during this task includes development of the final safety and accident prevention reports, final constructions progress reports, material receiving and exception reports, non-conformance reports and quality control reports.

### **5.5.2 Infrastructure Requirements**

- Identify, evaluate and contract for the most appropriate coal supply source. Develop a program of testing as received coal.

- Identify, evaluate and contract for the source of limestone. Develop a program for testing as received sorbent.
- Identify and contract for supplies of makeup water for the project.
- Contract for disposal of sanitary waste.
- Contract for disposal of solid waste materials from the gasification system to an approved landfill site.
- Perform systems studies with Nevada DOT to determine the need for highway upgrading. Identify routing of site access roadways and bridging requirements.

#### 5.5.3 Start-Up

- The objective of this task is to provide the resources for the precommissioning and initial systems operations for the project. Training, maintenance, safety, analysis and reporting procedures will be developed.

This task is divided into four subtasks:

- Provide the resources for all required training of operating staff, including development of the detailed operating procedures.
- Provide the resources required for the pre-commissioning and initial systems checkout of the project. Maintenance and safety procedures will be executed to verify their effectiveness.
- Provide the resources required for the commissioning and initial integrated operation of the project. Analysis and data acquisition procedures will be implemented. Methodology for reporting total demonstration plant performance results will be established.

- Perform all plant modifications including minor design revisions necessary to achieve acceptable demonstration plant performance at design specifications.

## **5.6 Environmental Permitting and Licensing**

The activities under this task include completion of all required environmental data collection, finalization of environmental and socioeconomic impact assessments, preparing the Environmental Monitoring Plan (EMP), obtaining required environment-related permits and incorporating health and safety considerations in design and operation. This task includes, but is not limited to, the following activities:

### **5.6.1 Environmental Studies**

Collect and analyze environmental data required to support the regulatory and permitting processes, the EMP requirements and the DOE effort in support of the National Environmental Policy Act (NEPA). Data to be collected include:

- Air Quality and Climatology
- Water Quality
- Terrestrial Ecology
- Geohydrology
- Noise
- Archaeological and Historical Resources
- Land and Water Use
- Socioeconomics
- Other requirements which may be added during the working sessions with federal, state and local agencies

Efforts include the following activities:

- Collect and analyze data on the physical, biological, cultural and socioeconomic environment that is required for permitting
- Collect, analyze and report information for the EMP Outline that describes the existing environment

### 5.6.2 Environmental Monitoring Plan Requirements

Develop an EMP Outline and an EMP that are acceptable to DOE and provide the reports agreed upon with DOE. These efforts include the following:

- Develop the EMP Outline
- Develop the EMP which will provide detailed descriptions of the tasks set forth in the EMP Outline
- Collect, analyze and report on the required information described in the EMP

### 5.6.3 Environmental Related Permits

Obtain the required environment-related permits for construction and operation of the project. Required permits include one or more each for discharges into the atmosphere, discharge of wastewater, construction in navigable airspace, earth disturbance, dams and impoundments, sewerage facilities, construction in floodplains, non-community water supply, solid waste disposal, hazardous waste disposal and land use. Activities under this task are scheduled to take place from the award of the cooperative agreement through obtaining operating permits and the permit for the solid waste disposal facility. The following tasks will be performed in the period from detailed design to commercial operation.

- State agency coordination will be a continuation of on-going activities wherein the regulatory agencies are updated on the design and schedule for the project and the project is updated on new and pending regulatory changes. This task supports the tasks that follow.
- A document will be prepared that will describe the regulations that must be met, the information required for the permit applications, and the schedule for application preparation.
- Design guidance will be provided consisting of a series of focused coordination activities wherein specific agreements on design and information details are negotiated with regulatory agencies and are then communicated to designers. The purpose of the design guidance activity is to develop permit applications that are complete

and in accordance with acceptable limits as submitted, thus expediting the permitting schedule.

- Permit applications will be prepared with the design, environmental and modeling information required, and with the required approved and supplemental documents (e.g., Erosion and Sedimentation, Control Plans, Endangered Species Survey, and Archaeological Reports for all activities that disturb the earth. Preparedness Prevention and Contingency Plan for the Industrial Waste permit).
- The regulatory agency review and analyses of permit applications will be expedited with prompt responses to agency comments and questions.
- The support necessary for public hearings will be provided that will result in overall favorable support for the project. Support activities include expert witnesses, environmental data and analyses and additional project information. Also included is the preparation of responses to questions and comments resulting from the public hearing and the written comment period.
- Permits and approvals will be obtained required for constructing the project, constructing the off-plot solid waste disposal facility, operating the project through start-up and shakedown, operating the project through the demonstration period, and making and supplying copies for DOE.

#### 5.6.4 Public and Occupational Health and Safety Analyses

Incorporate into the plant design and requirements of (Federal) Occupational Safety and Health Administration (OSHA) regulations, guidelines of the National Institute of Occupational Safety and Health (NIOSH), fire and safety codes, etc., that are applicable to the project. Effort will be applied to ensure that reliable health and safety programs for construction and plant operation phases will be developed. Specific activities to be completed are as follows:

- Incorporate health and safety considerations during design
- Provide training and implementation health and safety procedures for construction and operation

## **5.7 Start-Up and Operation**

This phase covers all the labor, materials and services needed for plant operation for a 42-month period during Phase III of the Piñon Pine Power Project. The objective is to provide all the operational and management direction that will be necessary to provide the private sector with technical, economic and environmental evaluations on the advanced coal gasification combined-cycle power plants.

### **5.7.1 Operations**

This task involves operating the gasifier system, combined-cycle power plant and associated systems at the required temperature, pressure, and coal and sorbent feed rates to meet the required power output of the facility. Specific data generated during this period of time include the following:

Operation - Plant operational data recorded by instruments and stored in the data acquisition system, daily operational logs, process or equipment anomalies, samples and chemical analysis of process and effluent streams as required, operational schedules and manhour records.

Plant Modifications - Modifications made to the facility in order to meet the required power output of the facility under various operating conditions.

Maintenance - Routine maintenance records, instrument repair records, compressor records, mechanical and rotating equipment records, pressure vessel certification, maintenance schedules, and manhours records.

This task is broken into three subtasks:

- Baseline operation of the plant using the design coal feeds.
- SPPCo will obtain sufficient operating data on high sulfur coals to enhance the marketing and licensing of this technology to a broad based energy sector.
- The plant will be modified based on the experience of extended operations on both high and low sulfur coals.

### 5.7.2 Data Collection and Reporting

The purpose of this task is to collect the process performance data gathered on the 42-month operational phase of the Project and summarize it in a form that will be useful for the technical, economic and environmental evaluation of the advanced coal gasification combined-cycle. Data generated and maintained during this period will include the following:

- Monthly summary of minimum and maximum performance, monthly summary or process performance anomalies, heat and energy balance for selected performance periods, monthly summary of chemical/physical analysis, test plant/schedule for special performance testing, maintenance of instrument configuration drawings, maintenance of piping and instrument diagrams and process flow diagrams, document equipment modifications and equipment list changes.

## **6.0 TECHNICAL IMPACTS ON SCHEDULE**

The Project Schedule has changed since the start of the project to include changes resulting from key project decisions. Phased installation of the combustion turbine, combined-cycle and coal gasification areas has been changed to installation of the total project in one construction cycle. This change came through SPPCo's changing load forecast and the development of a more efficient plant through improvements in available hardware.

SPPCo's load forecast required the installation of two (2) combustion turbines for peaking generation. These units, to be operational June 1994, removed the need for the phased installation of the Piñon Pine Power Project. By allowing the project's construction to not be hindered by the restraints of unit operation and a stretched construction schedule, installation costs will be reduced.

The development of a new, high firing temperature, combustion turbine by GE and the decision not to use the steam use intensive zinc ferrite sulfur sorbent, resulted in further improvements in cycle efficiency.

These changes eliminated the phase implementation while maintaining December 1996 as the date for operation on coal. The current schedule requires a Record of Decision on the EIS in August 1994 and a Permit to Construct in January 1995.



A Summary Bar Chart Project Schedule is included in Appendix 4.

## **7.0 CONCLUSIONS AND LOOK AHEAD**

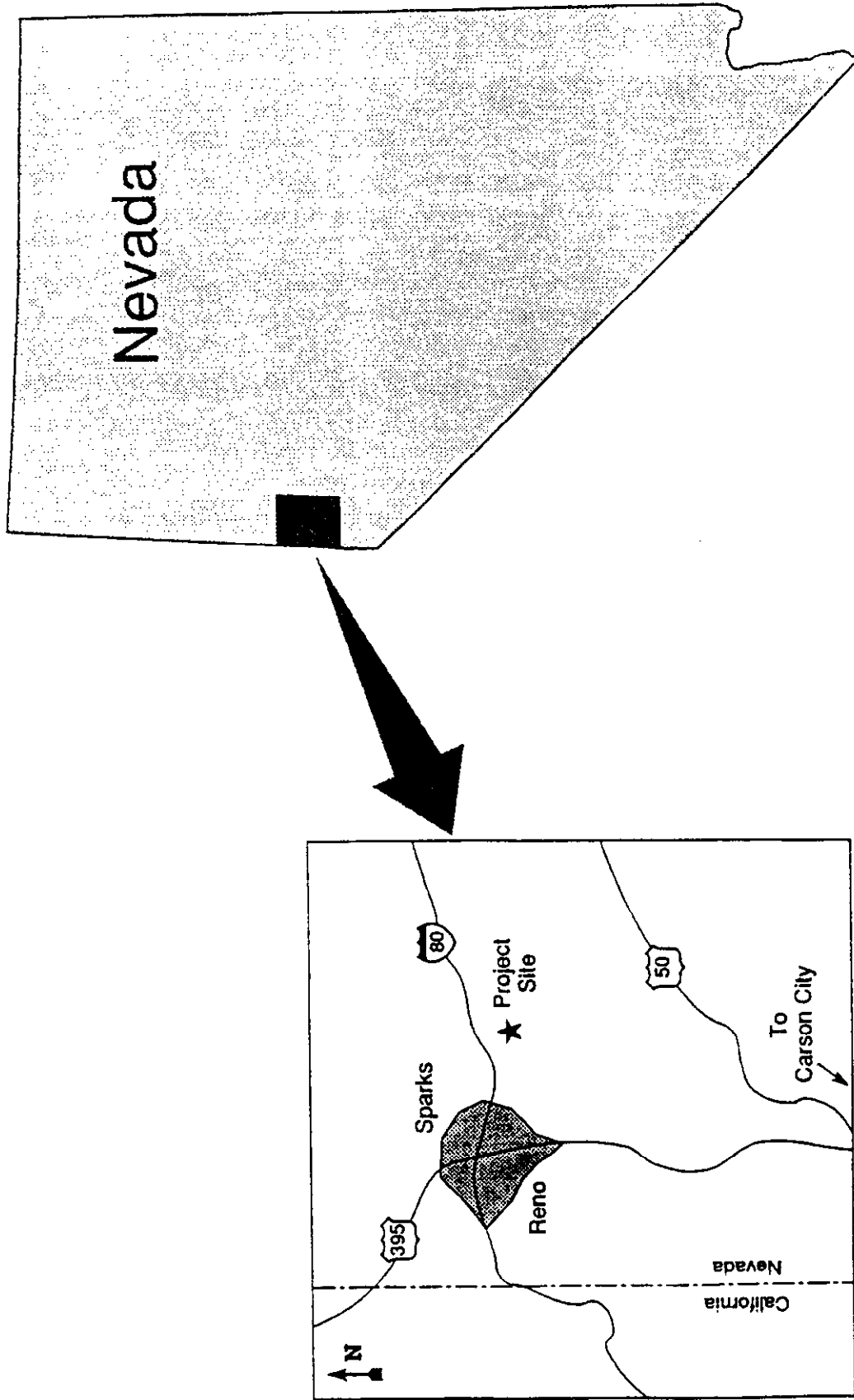
SPPCo will complete the data collection for the PSD Permit and complete its Utility Environmental Protection Act (UEPA) filing with the State of Nevada. The UEPA application will require a favorable Record of Decision on the EIS. Assuming that the Record of Decision is received in August, the UEPA filing will be completed. The resulting Permit to Construct will be issued allowing construction to start in January 1995.

During the first quarter of 1994, Phase I Design activities will continue including the following major activities:

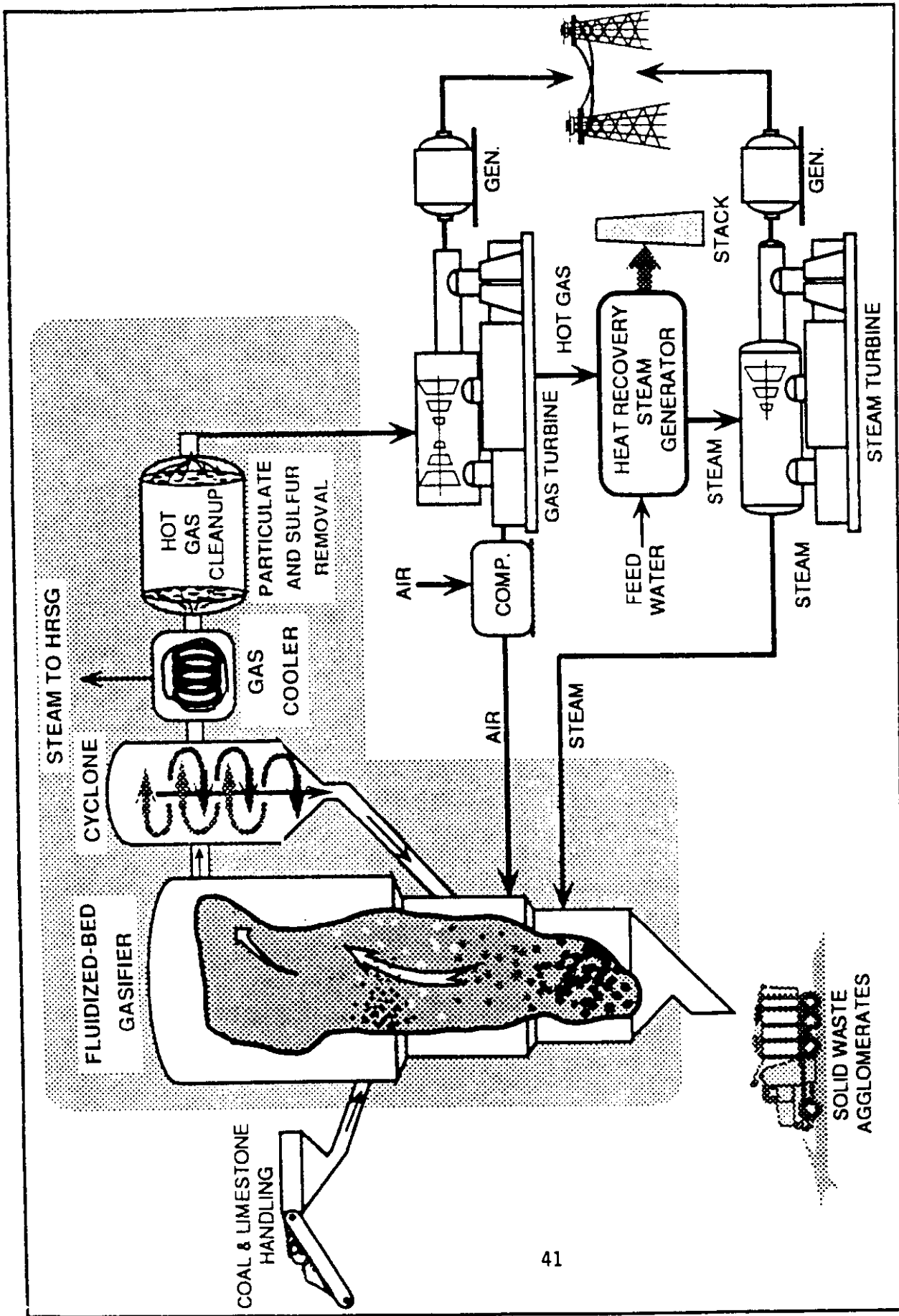
- Start development of piping and instrument diagrams
- Start development of equipment arrangement drawings
- Issue major equipment requisitions for inquiry such as heat recovery steam generator and steam turbine generator
- Issue final project specifications
- Release subcontracts for site survey and geotechnical investigation
- Complete Class III Estimate

## **8.0 APPENDICES**

1. Location of Piñon Pine IGCC Power Project
2. Piñon Pine IGCC Power Project Schematic
3. Process Flow Diagrams
4. Summary Bar Chart Project Schedule
5. Photographs of existing Tracy facility



Appendix 1. Location of Piñon Pine IGCC Power Project



Appendix 2. Piñon Pine IGCC Power Project Schematic

### APPENDIX 3

#### PROCESS FLOW DIAGRAMS/HEAT & MATERIAL BALANCES

<u>Drawing No.</u>	<u>Title</u>
4141-2-50-112	Oxidant Compression and Supply Coal Gasification Section 200 & 300
4141-2-50-113	Coal Gasification - Section 300
4141-2-50-114	Gas Stream Heat Recovery - Section 400 Gas Stream Particulate Removal - Section 500 Recycle Gas Compression - Section 900
4141-2-50-115	Desulfurization (Fuel Gas) - Section 600
4141-2-50-116	Gas Stream Particulate Removal - Section 500
4141-2-50-117	Desulfurization and Waste Solids Treatment - Section 600
4142-2-50-210	Section 700 - Gas Turbine Generator
4142-2-50-211	Section 800 - Heat Recovery Steam Generator
4142-2-50-212	Section 800 - Steam Turbine Generator
4142-2-50-213	Section 800 - Deaerator Heater & B.D. Drums
4143-2-50-310	Clean Coal IV - Section 100 Solids Receiving, Drying & Crushing
4143-2-50-311	Section 1000 - Wastewater Treatment
4143-2-50-312	Section 1100 - Solid Waste Handling System
4143-2-50-313	Section 1200 - Boiler Feedwater Treatment
4143-2-50-314	Section 1200 - Cooling Water System
4143-2-50-315	Section 1200 - River & Raw Water Systems
4143-2-50-316	Section 1200 - Boiler Water Treatment
4143-2-50-317	Section 1200 - Instrument & Plant Air System
4143-2-50-318	Section 1200 - Flare System
4143-2-50-319	Section 1200 - Propane System
-	MWK Gasifier Island Heat & Material Balance - Base Case dated July 27, 1993
-	FWUSA Combined Cycle Heat Balance Diagram - Base Case dated November 2, 1993

MWK J-7514  
1 OF 16  
27 JUL 93  
REV. 0

**SIERRA PACIFIC POWER COMPANY  
PIÑON PINE POWER PROJECT  
RENO, NEVADA**

**HEAT AND MATERIAL BALANCE - BASE CASE  
THE M. W. KELLOGG COMPANY  
JOB 7514**

DATE	REV #	PREP'D	CHECKED	CTE APPR
27 Jul 93	0	FE	<i>gum</i>	<i>[Signature]</i>



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	1		2		3		4	
		Prepared Coal Feedstock		Limestone Feedstock		Ash Withdrawal From Gasifier		Coal Transp Air	
		Wt%	Lb/Hr	Wt%	Lb/Hr	Wt%	Lb/Hr	Vol%	Lb
-----									
GASES:									
Carbon Monoxide	28.01								0.00
Hydrogen	2.02								0.00
Carbon Dioxide	44.01								0.00
Methane	16.04								0.00
Nitrogen	28.01								77.99
Argon	39.95								0.90
Oxygen	32.00								20.82
Ammonia	17.03								0.00
Hydrogen Sulfide	34.08								0.00
Carbonyl Sulfide	60.08								0.00
Sulfur Dioxide	64.06								0.00
Water Vapor	18.02								0.29
Hydrogen Chloride	36.46								0.00
									-----
TOTAL GASES									100.00
Gas Flow, Lb Moles/Hr									
Molecular Weight, Gases									
Gas Volume, ACFM									
Gas Volume, SCFM									
LIQUIDS:									
Water	18.02								
SOLIDS:									
Carbon	12.01	68.29	46,466			27.19	1,778		
Hydrogen	1.01	4.64	3,155			0.07	5		
Oxygen	16.00	12.04	8,195			0.35	23		
Nitrogen	14.01	1.01	687			0.22	14		
Sulfur	32.06	0.35	241			0.17	11		
Chlorides	35.45	0.00	0			0.00	0		
Ash		9.67	6,580			72.00	4,708		
Moisture	18.02	4.00	2,722			0.00	0		
		-----	-----			-----	-----		
TOTAL SOLIDS		100.00	68,045			100.00	6,539		
SORBENT:									
CaO	56.08			0.00	0	76.65	1,127		
CaCO3	100.09			90.04	3,007	0.00	0		
CaS	72.14			0.00	0	10.23	150		
CaSO4	136.14			0.00	0	0.00	0		
MgO	40.31			0.00	0	3.28	48		
MgCO3	84.32			4.09	137	0.00	0		
Inerts				5.87	196	9.84	145		
				-----	-----	-----	-----		
TOTAL SORBENT				100.00	3,340	100.00	1,471		
TOTAL FLOW, Lb/Hr			68,045		3,340		8,010		
HEATING VALUE:									
Gas LHV, Btu/SCF									
Gaseous Fuel LHV, MMBtu/hr									
-----									
TEMPERATURE, F			50		50		500		
PRESSURE, PSIA			13		13		355		



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	5		6		7		8	
		Process Air To Gasifier		Product Gas From Gasifier		Product Gas From Cyclone		Total Air From Gas Turbine	
		Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr
<b>GASES:</b>									
Carbon Monoxide	28.01	0.00	0	24.48	82,478	24.48	82,478	0.00	0
Hydrogen	2.02	0.00	0	15.12	3,666	15.12	3,666	0.00	0
Carbon Dioxide	44.01	0.00	0	5.17	27,360	5.17	27,360	0.00	0
Methane	16.04	0.00	0	1.32	2,542	1.32	2,542	0.00	0
Nitrogen	28.01	77.99	141,222	48.03	161,870	48.03	161,870	78.00	154,073
Argon	39.95	0.90	2,316	0.55	2,643	0.55	2,643	0.90	2,527
Oxygen	32.00	20.82	43,063	0.00	0	0.00	0	20.82	46,982
Ammonia	17.03	0.00	0	0.02	33	0.02	33	0.00	0
Hydrogen Sulfide	34.08	0.00	0	0.03	119	0.03	119	0.00	0
Carbonyl Sulfide	60.08	0.00	0	0.00	22	0.00	22	0.00	0
Sulfur Dioxide	64.06	0.00	0	0.00	0	0.00	0	0.00	0
Water Vapor	18.02	0.29	333	5.29	11,458	5.29	11,458	0.29	363
Hydrogen Chloride	36.46	0.00	0	0.00	0	0.00	0	0.00	0
<b>TOTAL GASES</b>		<b>100.00</b>	<b>186,934</b>	<b>100.00</b>	<b>292,190</b>	<b>100.00</b>	<b>292,190</b>	<b>100.00</b>	<b>203,945</b>
Gas Flow, Lb Moles/Hr			6463.5		12029.4		12029.4		7,051.7
Molecular Weight, Gases			28.92		24.29		24.29		28.92
Gas Volume, ACFM			3167.2		14,173.0		14,173.0		8,127.9
Gas Volume, SCFM			40,868		76,060		76,060		44,587
<b>LIQUIDS:</b>									
Water	18.02								
<b>SOLIDS:</b>									
				Wt%		Wt%			
Carbon	12.01			54.20	32,943	54.20	2,306		
Hydrogen	1.01			0.32	197	0.32	14		
Oxygen	16.00			0.70	425	0.70	30		
Nitrogen	14.01			0.41	248	0.41	17		
Sulfur	32.06			0.36	221	0.36	15		
Chlorides	35.45			0.00	0	0.00	0		
Ash				44.00	26,742	44.00	1,872		
Moisture	18.02			0.00	0	0.00	0		
<b>TOTAL SOLIDS</b>				<b>100.00</b>	<b>60,778</b>	<b>100.00</b>	<b>4,254</b>		
<b>SORBENT:</b>									
CaO	56.08			76.65	19,964	76.65	399		
CaCO3	100.09			0.00	0	0.00	0		
CaS	72.14			10.23	2,665	10.23	53		
CaSO4	136.14			0.00	0	0.00	0		
MgO	40.31			3.28	854	3.28	17		
MgCO3	84.32			0.00	0	0.00	0		
Inerts				9.84	2,564	9.84	51		
<b>TOTAL SORBENT</b>				<b>100.00</b>	<b>26,047</b>	<b>100.00</b>	<b>521</b>		
<b>TOTAL FLOW, Lb/Hr</b>			<b>186,934</b>		<b>379,015</b>		<b>296,965</b>		<b>203,945</b>
<b>HEATING VALUE:</b>									
Gas LHV, Btu/SCF					132		132		-
Gaseous Fuel LHV, MMbtu/hr					603.26		603.26		
<b>TEMPERATURE, F</b>									
<b>TEMPERATURE, F</b>			<b>650</b>		<b>1,800</b>		<b>1,800</b>		<b>707</b>
<b>PRESSURE, PSIA</b>									
<b>PRESSURE, PSIA</b>			<b>410</b>		<b>345</b>		<b>344</b>		<b>182</b>



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCA COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	9		10		11		12	
		Recycle Gas To Grid		Steam to Gasifier		Recycle Gas to Annulus		Gas From Product Gas Cooler	
		Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr
GASES:									
Carbon Monoxide	28.01	24.49	109			24.49	3,079	24.48	82.4
Hydrogen	2.02	15.12	5			15.12	137	15.12	3.6
Carbon Dioxide	44.01	5.17	36			5.17	1,022	5.17	27.3
Methane	16.04	1.32	3			1.32	95	1.32	2.5
Nitrogen	28.01	48.06	214			48.06	6,042	48.03	161.8
Argon	39.95	0.55	3			0.55	99	0.55	2.6
Oxygen	32.00	0.00	0			0.00	0	0.00	
Ammonia	17.03	0.02	0			0.02	1	0.02	
Hydrogen Sulfide	34.08	0.00	0			0.00	0	0.03	1
Carbonyl Sulfide	60.08	0.00	0			0.00	0	0.00	
Sulfur Dioxide	64.06	0.00	0			0.00	0	0.00	
Water Vapor	18.02	5.27	15	100.00	16,651	5.27	426	5.29	11.4
Hydrogen Chloride	36.46	0.00	0			0.00	0	0.00	
TOTAL GASES		100.00	387	100.00	16,651	100.00	10,900	100.00	292.1
Gas Flow, Lb Moles/Hr			15.9		924.3		448.8		12029
Molecular Weight, Gases			24.29		18.02		24.29		24.
Gas Volume, ACFM			6.1		441.2		171.3		9,491
Gas Volume, SCFM			101		5,845		2,838		76.0
LIQUIDS:									
Water	18.02								
SOLIDS:									
Carbon	12.01							Wt%	
Hydrogen	1.01							54.20	2.3
Oxygen	16.00							0.32	
Nitrogen	14.01							0.70	
Sulfur	32.06							0.41	
Chlorides	35.45							0.36	
Ash								0.00	
Moisture	18.02							44.00	1.8
TOTAL SOLIDS								0.00	
								100.00	4.2
SORBENT:									
CaO	56.08							76.65	3
CaCO3	100.09							0.00	
CaS	72.14							10.23	
CaSO4	136.14							0.00	
MgO	40.31							3.28	
MgCO3	84.32							0.00	
Inerts								9.84	
TOTAL SORBENT								100.00	5
TOTAL FLOW, Lb/Hr			387		16,651		10,900		296.9
HEATING VALUE:									
Gas LHV, Btu/SCF			132		-		132		1
Gaseous Fuel LHV, MMBtu/hr			0.80				22.48		603.
TEMPERATURE, F									
			385		600		385		1.0
PRESSURE, PSIA			400		400		400		3





HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	13		14 (Note 1)		15		16 (Note 1)	
		Condensate From		Blowback Gas		High Pressure		Pressurization	
		Recycle Gas		to Filter		Recycle Gas		Recycle Gas	
		Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr
GASES:									
Carbon Monoxide	28.01			25.68	877	25.68	974	25.68	97
Hydrogen	2.02			15.85	39	15.85	43	15.85	4
Carbon Dioxide	44.01			5.42	291	5.42	323	5.42	32
Methane	16.04			1.38	27	1.38	30	1.38	3
Nitrogen	28.01			50.39	1,722	50.39	1,912	50.39	191
Argon	39.95			0.58	28	0.58	31	0.58	3
Oxygen	32.00			0.01	0	0.01	0	0.01	0
Ammonia	17.03			0.00	0	0.00	0	0.00	0
Hydrogen Sulfide	34.08			0.00	0	0.00	0	0.00	0
Carbonyl Sulfide	60.08			0.00	0	0.00	0	0.00	0
Sulfur Dioxide	64.06			0.00	0	0.00	0	0.00	0
Water Vapor	18.02			0.70	15	0.70	17	0.70	2
Hydrogen Chloride	36.46			0.00	0	0.00	0	0.00	0
TOTAL GASES				100.00	3,000	100.00	3,332	100.00	332
Gas Flow, Lb Moles/Hr					122.0	135.5		13.5	
Molecular Weight, Gases					24.59	24.59		24.59	
Gas Volume, ACFM					26.3	29.2		2.9	
Gas Volume, SCFM					771	857		85	
LIQUIDS:									
Water	18.02	100.00	118						
SOLIDS:									
Carbon	12.01								
Hydrogen	1.01								
Oxygen	16.00								
Nitrogen	14.01								
Sulfur	32.06								
Chlorides	35.45								
Ash									
Moisture	18.02								
TOTAL SOLIDS									
SORBENT:									
CaO	56.08								
CaCO3	100.09								
CaS	72.14								
CaSO4	136.14								
MgO	40.31								
MgCO3	84.32								
Inerts									
TOTAL SORBENT									
TOTAL FLOW, Lb/Hr			118	3,000		3,332		332	
HEATING VALUE:									
Gas LHV, Btu/SCF					138	138		138	
Gaseous Fuel LHV, MMbtu/hr					6.41	7.11		0.71	
TEMPERATURE, F									
PRESSURE, PSIA			120	367		367		367	
			260	700		700		700	

Note 1: Streams 14 and 16 are time averaged flow rate.



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	17 (Note 1) Sorbent Regeneration Product Gas		18 Cooled Recycle Gas		19 (Note 1) Pressurization Air		20 Hot Recycle Gas	
		Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr
GASES:									
Carbon Monoxide	28.01	0.00	0	24.49	5,348	0.00	0	24.49	5,
Hydrogen	2.02	0.00	0	15.12	238	0.00	0	15.12	
Carbon Dioxide	44.01	0.00	0	5.17	1,775	0.00	0	5.17	1,
Methane	16.04	0.00	0	1.32	165	0.00	0	1.32	
Nitrogen	28.01	98.36	8,722	48.06	10,496	77.99	816	48.06	10,
Argon	39.95	0.50	64	0.55	171	0.90	13	0.55	
Oxygen	32.00	0.00	0	0.00	0	20.82	249	0.00	
Ammonia	17.03	0.00	0	0.02	2	0.00	0	0.02	
Hydrogen Sulfide	34.08	0.00	0	0.00	1	0.00	0	0.00	
Carbonyl Sulfide	60.08	0.00	0	0.00	0	0.00	0	0.00	
Sulfur Dioxide	64.06	1.14	231	0.00	0	0.00	0	0.00	
Water Vapor	18.02	0.00	0	5.27	740	0.29	2	5.27	
Hydrogen Chloride	36.46	0.00	0	0.00	0	0.00	0	0.00	
TOTAL GASES		100.00	9,017	100.00	18,936	100.00	1,080	100.00	18,
Gas Flow, Lb Moles/Hr			316.5		779.7		37.4		77
Molecular Weight, Gases			28.48		24.29		28.92		24
Gas Volume, ACFM			2,917.3		378.9		9.8		74
Gas Volume, SCFM			2,002		4,930		236		4,
LIQUIDS:									
Water	18.02								
SOLIDS:									
Carbon	12.01								
Hydrogen	1.01								
Oxygen	16.00								
Nitrogen	14.01								
Sulfur	32.06								
Chlorides	35.45								
Ash									
Moisture	18.02								
TOTAL SOLIDS									
SORBENT:									
CaO	56.08								
CaCO3	100.09								
CaS	72.14								
CaSO4	136.14								
MgO	40.31								
MgCO3	84.32								
Inerts									
TOTAL SORBENT									
TOTAL FLOW, Lb/Hr			9,017		18,936		1,080		18,
HEATING VALUE:									
Gas LHV, Btu/SCF			-		132				
Gaseous Fuel LHV, MMBtu/hr					39.06				39
TEMPERATURE, F									
PRESSURE, PSIA			1,342		270		120		1,
			35		270		395		

Note 1: Streams 17 and 19 are time averaged flow rates.



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	21		22		23		24	
		Air to Sulfator		Sulfator Flue Gas to Vent		Solids From Sulfator		Total Solids to Disposal	
		Vol%	Lb/Hr	Vol%	Lb/Hr	Wt%	Lb/Hr	Wt%	Lb/Hr
GASES:									
Carbon Monoxide	28.01	0.00	0	0.00	0				
Hydrogen	2.02	0.00	0	0.00	0				
Carbon Dioxide	44.01	0.00	0	14.45	16,292				
Methane	16.04	0.00	0	0.00	0				
Nitrogen	28.01	77.99	46,976	79.87	57,306				
Argon	39.95	0.90	771	0.84	860				
Oxygen	32.00	20.82	14,324	2.91	2,387				
Ammonia	17.03	0.00	0	0.00	0				
Hydrogen Sulfide	34.08	0.00	0	0.00	0				
Carbonyl Sulfide	60.08	0.00	0	0.00	0				
Sulfur Dioxide	64.06	0.00	0	0.02	28				
Water Vapor	18.02	0.29	111	1.90	878				
Hydrogen Chloride	36.46	0.00	0	0.00	0				
TOTAL GASES		100.00	62,182	100.00	77,752				
Gas Flow, Lb Moles/Hr			2150.0		2,561.2				
Molecular Weight, Gases			28.92		30.36				
Gas Volume, ACFM			7,520.8		17,405.2				
Gas Volume, SCFM			13,594		16,194				
LIQUIDS:									
Water	18.02								
SOLIDS:									
Carbon	12.01					1.22	81	1.22	82
Hydrogen	1.01					0.00	0	0.00	0
Oxygen	16.00					0.79	52	0.79	53
Nitrogen	14.01					0.46	30	0.46	31
Sulfur	32.06					0.01	1	0.01	1
Chlorides	35.45					0.00	0	0.00	0
Ash						97.53	6,469	97.53	6,580
Moisture	18.02					0.00	0	0.00	0
TOTAL SOLIDS						100.00	6,633	100.00	6,747
SORBENT:									
CaO	56.08					52.34	1,282	52.34	1,304
CaCO3	100.09					0.00	0	0.00	0
CaS	72.14					0.00	0	0.00	0
CaSO4	136.14					37.17	910	37.17	926
MgO	40.31					2.62	64	2.62	65
MgCO3	84.32					0.00	0	0.00	0
Inerts						7.87	193	7.87	196
TOTAL SORBENT						100.00	2,449	100.00	2,491
TOTAL FLOW, Lb/Hr			62,182		77,752		9,082		9,238
HEATING VALUE:									
Gas LHV, Btu/SCF			-		-				
Gaseous Fuel LHV, MMBtu/hr									
TEMPERATURE, F									
TEMPERATURE, F			322		300		1,600		150
PRESSURE, PSIA			40		13		25		13



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	25		26		27		28 (Note 1)		
		Cyclone Fines to Gasifier		Product Gas to Sorbent Reactors		Product Gas From Sorbent Reactors		Regeneration Air to Sorbent Reactor		
		Wt%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	
GASES:										
Carbon Monoxide	28.01			24.49	83,355	24.49	83,355	0.00		
Hydrogen	2.02			15.12	3,705	15.12	3,705	0.00		
Carbon Dioxide	44.01			5.17	27,652	5.17	27,668	0.00		
Methane	16.04			1.32	2,569	1.32	2,569	0.00		
Nitrogen	28.01			48.06	163,592	48.06	163,592	78.00		
Argon	39.95			0.55	2,671	0.55	2,671	0.90		
Oxygen	32.00			0.00	0	0.00	0	20.82		
Ammonia	17.03			0.02	33	0.02	33	0.00		
Hydrogen Sulfide	34.08			0.03	119	0.00	8	0.00		
Carbonyl Sulfide	60.08			0.00	22	0.00	0	0.00		
Sulfur Dioxide	64.06			0.00	0	0.00	0	0.00		
Water Vapor	18.02			5.24	11,473	5.27	11,531	0.29		
Hydrogen Chloride	36.46			0.00	0	0.00	0	0.00		
TOTAL GASES				100.00	295,191	100.00	295,132	100.00		
Gas Flow, Lb Moles/Hr					12,151.0	12,151.0				
Molecular Weight, Gases					24.30	24.29				
Gas Volume, ACFM					9,690.5	11,026.4				
Gas Volume, SCFM					76,832	76,832				
LIQUIDS:										
Water	18.02									
SOLIDS:										
Carbon	12.01	54.20	30,637							
Hydrogen	1.01	0.32	184							
Oxygen	16.00	0.70	396							
Nitrogen	14.01	0.41	231							
Sulfur	32.06	0.36	206							
Chlorides	35.45	0.00	0							
Ash		44.00	24,871							
Moisture	18.02	0.00	0							
TOTAL SOLIDS		100.00	56,524							
SORBENT:										
CaO	56.08	76.65	19,565							
CaCO3	100.09	0.00	0							
CaS	72.14	10.23	2,611							
CaSO4	136.14	0.00	0							
MgO	40.31	3.28	837							
MgCO3	84.32	0.00	0							
Inerts		9.84	2,513							
TOTAL SORBENT		100.00	25,526							
TOTAL FLOW, Lb/Hr			82,050	295,191			295,132			
HEATING VALUE:										
Gas LHV, Btu/SCF					132	132				
Gaseous Fuel LHV, MMBtu/hr					609.69	608.74				
TEMPERATURE, F										
PRESSURE, PSIA			1,790	1,000			1,001			
			344	330			290			

Note 1: Flow rate denotes intermediate value and will be confirmed later.



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	29 (Note 1) Regeneration Gas From Start-up Heater		30 Ash Transport Gas		31 Fines Transport Gas		32 Product Gas to Gas Turbine	
		Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr
GASES:									
Carbon Monoxide	28.01	0.00	0	24.49	452	24.49	270	24.49	78,007
Hydrogen	2.02	0.00	0	15.12	20	15.12	12	15.12	3,467
Carbon Dioxide	44.01	0.00	0	5.17	150	5.17	89	5.17	25,892
Methane	16.04	0.00	0	1.32	14	1.32	8	1.32	2,404
Nitrogen	28.01	97.80	8,722	48.06	888	48.06	529	48.06	153,090
Argon	39.95	0.50	64	0.55	14	0.55	9	0.55	2,500
Oxygen	32.00	1.70	173	0.00	0	0.00	0	0.00	0
Ammonia	17.03	0.00	0	0.02	0	0.02	0	0.02	31
Hydrogen Sulfide	34.08	0.00	0	0.00	0	0.00	0	0.00	8
Carbonyl Sulfide	60.08	0.00	0	0.00	0	0.00	0	0.00	0
Sulfur Dioxide	64.06	0.00	0	0.00	0	0.00	0	0.00	0
Water Vapor	18.02	0.00	0	5.27	63	5.27	37	5.27	10,791
Hydrogen Chloride	36.46	0.00	0	0.00	0	0.00	0	0.00	0
TOTAL GASES		100.00	8,959	100.00	1,602	100.00	955	100.00	276,190
Gas Flow, Lb Moles/Hr			318.4		66.0		39.3		11,372.0
Molecular Weight, Gases			28.14		24.29		24.29		24.29
Gas Volume, ACFM			1,749.9		32.1		19.1		10,869.3
Gas Volume, SCFM			2,013		417		248		71,902
LIQUIDS:									
Water	18.02								
SOLIDS:									
Carbon	12.01								
Hydrogen	1.01								
Oxygen	16.00								
Nitrogen	14.01								
Sulfur	32.06								
Chlorides	35.45								
Ash									
Moisture	18.02								
TOTAL SOLIDS									
SORBENT:									
CaO	56.08								
CaCO3	100.09								
CaS	72.14								
CaSO4	136.14								
MgO	40.31								
MgCO3	84.32								
Inerts									
TOTAL SORBENT									
TOTAL FLOW, Lb/Hr			8,959		1,602		955		276,190
HEATING VALUE:									
Gas LHV, Btu/SCF					132		132		132
Gaseous Fuel LHV, MMBtu/hr					3.30		1.97		569.67
TEMPERATURE, F									
TEMPERATURE, PSIA			1,075		270		270		1,000
			50		270		270		275

Note 1: Flow rate denotes intermediate value and will be confirmed later.



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	33		34		35		36	
		Total Ash/Fines Transport Gas		Sorbent Regeneration Dilution Gas		BFW Blowdown From Sulfator Steam Drum		Sulfator Fines to Disposal	
		Wt%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Wt%	Lb/Hr
GASES:									
Carbon Monoxide	28.01	24.49	722	0.00	0				
Hydrogen	2.02	15.12	32	0.00	0				
Carbon Dioxide	44.01	5.17	240	0.00	0				
Methane	16.04	1.32	22	0.00	0				
Nitrogen	28.01	48.06	1,417	97.80	8,722				
Argon	39.95	0.55	23	0.50	64				
Oxygen	32.00	0.00	0	1.70	173				
Ammonia	17.03	0.02	0	0.00	0				
Hydrogen Sulfide	34.08	0.00	0	0.00	0				
Carbonyl Sulfide	60.08	0.00	0	0.00	0				
Sulfur Dioxide	64.06	0.00	0	0.00	0				
Water Vapor	18.02	5.27	100	0.00	0				
Hydrogen Chloride	36.46	0.00	0	0.00	0				
TOTAL GASES		100.00	2,557	100.00	8,959				
Gas Flow, Lb Moles/Hr			105.3		318.4				
Molecular Weight, Gases			24.29		28.14				
Gas Volume, ACFM			51.2						
Gas Volume, SCFM			666		2,013				
LIQUIDS:									
Water	18.02					100.00	685		
SOLIDS:									
Carbon	12.01							1.22	
Hydrogen	1.01							0.00	
Oxygen	16.00							0.79	
Nitrogen	14.01							0.46	
Sulfur	32.06							0.01	
Chlorides	35.45							0.00	
Ash								97.53	
Moisture	18.02							0.00	
TOTAL SOLIDS								100.00	
SORBENT:									
CaO	56.08							52.34	
CaCO3	100.09							0.00	
CaS	72.14							0.00	
CaSO4	136.14							37.17	
MgO	40.31							2.62	
MgCO3	84.32							0.00	
Inerts								7.87	
TOTAL SORBENT								100.00	
TOTAL FLOW, Lb/Hr			2,557		8,959		685		
HEATING VALUE:									
Gas LHV, Btu/SCF			132						
Gaseous Fuel LHV, MMBtu/hr			5.27						
TEMPERATURE, F									
			270		85		538		1.
PRESSURE, PSIA									
			270		75		950		



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	37		38		39		40	
		Filter Solids From Screw Cooler		Gas From Sulfator Cyclone		Gas From Flue Gas Cooler		NOT USED	
		Wt%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr
GASES:									
Carbon Monoxide	28.01			0.00	0	0.00	0		
Hydrogen	2.02			0.00	0	0.00	0		
Carbon Dioxide	44.01			14.45	16,292	14.45	16,292		
Methane	16.04			0.00	0	0.00	0		
Nitrogen	28.01			79.87	57,306	79.87	57,306		
Argon	39.95			0.84	860	0.84	860		
Oxygen	32.00			2.91	2,387	2.91	2,387		
Ammonia	17.03			0.00	0	0.00	0		
Hydrogen Sulfide	34.08			0.00	0	0.00	0		
Carbonyl Sulfide	60.08			0.00	0	0.00	0		
Sulfur Dioxide	64.06			0.02	28	0.02	28		
Water Vapor	18.02			1.90	878	1.90	878		
Hydrogen Chloride	36.46			0.00	0	0.00	0		
TOTAL GASES				100.00	77,752	100.00	77,752		
Gas Flow, Lb Moles/Hr					2,561.2	2,561.2			
Molecular Weight, Gases					30.36	30.36			
Gas Volume, ACFM					31,468.4	19,754.1			
Gas Volume, SCFM					16,194	16,194			
LIQUIDS:									
Water	18.02								
SOLIDS:									
Carbon	12.01	54.20	2,306	1.22	1	1.22	1		
Hydrogen	1.01	0.32	14	0.00	0	0.00	0		
Oxygen	16.00	0.70	30	0.79	1	0.79	1		
Nitrogen	14.01	0.41	17	0.46	1	0.46	1		
Sulfur	32.06	0.36	15	0.01	0	0.01	0		
Chlorides	35.45	0.00	0	0.00	0	0.00	0		
Ash		44.00	1,872	97.53	111	97.53	111		
Moisture	18.02	0.00	0	0.00	0	0.00	0		
TOTAL SOLIDS		100.00	4,254	100.00	114	100.00	114		
SORBENT:									
CaO	56.08	76.65	399	52.34	22	52.34	22		
CaCO3	100.09	0.00	0	0.00	0	0.00	0		
CaS	72.14	10.23	53	0.00	0	0.00	0		
CaSO4	136.14	0.00	0	37.17	16	37.17	16		
MgO	40.31	3.28	17	2.62	1	2.62	1		
MgCO3	84.32	0.00	0	0.00	0	0.00	0		
Inerts		9.84	51	7.87	3	7.87	3		
TOTAL SORBENT		100	521	100.00	42	100.00	42		
TOTAL FLOW, Lb/Hr			4,775	77,908			77,908		
HEATING VALUE:									
Gas LHV, Btu/SCF					-	-			
Gaseous Fuel LHV, MMBtu/hr									
-----									
TEMPERATURE, F			500	1,600			834		
PRESSURE, PSIA			330	30			30		



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCA COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	41		42		43 (Note 1)		44 (Note 1)	
		Total BFW From Sec. 800		Recycle Gas From Compressor		Ash Hopper Vent Gas		Fines Hopper Vent Gas	
		Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr
GASES:									
Carbon Monoxide	28.01			24.49	3,652	25.68	59	25.68	3
Hydrogen	2.02			15.12	162	15.85	3	15.85	1
Carbon Dioxide	44.01			5.17	1,212	5.42	20	5.42	1
Methane	16.04			1.32	113	1.38	2	1.38	1
Nitrogen	28.01			48.06	7,166	50.39	115	50.39	7
Argon	39.95			0.55	117	0.58	2	0.58	1
Oxygen	32.00			0.00	0	0.01	0	0.01	0
Ammonia	17.03			0.02	1	0.00	0	0.00	0
Hydrogen Sulfide	34.08			0.00	0	0.00	0	0.00	0
Carbonyl Sulfide	60.08			0.00	0	0.00	0	0.00	0
Sulfur Dioxide	64.06			0.00	0	0.00	0	0.00	0
Water Vapor	18.02			5.27	505	0.70	1	0.70	1
Hydrogen Chloride	36.46			0.00	0	0.00	0	0.00	0
TOTAL GASES				100.00	12,929	100.00	201	100.00	1
Gas Flow, Lb Moles/Hr					532.3	8.2		5	
Molecular Weight, Gases					24.29	24.59		24.	
Gas Volume, ACFM					203.1	1.8		1	
Gas Volume, SCFM					3,366	52			
LIQUIDS:									
Water	18.02	100.00	130,764						
SOLIDS:									
Carbon	12.01								
Hydrogen	1.01								
Oxygen	16.00								
Nitrogen	14.01								
Sulfur	32.06								
Chlorides	35.45								
Ash									
Moisture	18.02								
TOTAL SOLIDS									
SORBENT:									
CaO	56.08								
CaCO3	100.09								
CaS	72.14								
CaSO4	136.14								
MgO	40.31								
MgCO3	84.32								
Inerts									
TOTAL SORBENT									
TOTAL FLOW, Lb/Hr			130,764	12,929		201			
HEATING VALUE:									
Gas LHV, Btu/SCF					132	138			
Gaseous Fuel LHV, MMBtu/hr					26.67	0.43		0	
TEMPERATURE, F									
			230	385		367			
PRESSURE, PSIA									
			1,000	400		700			

Note: 1. Streams 43 and 44 are time averaged flow rates.





HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	45		46		47		48	
		BFW to Air Precooler		BFW From Air Precooler		BFW to Recycle Gas Cooler		BFW From Recycle Gas Cooler	
		Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr
GASES:									
Carbon Monoxide	28.01								
Hydrogen	2.02								
Carbon Dioxide	44.01								
Methane	16.04								
Nitrogen	28.01								
Argon	39.95								
Oxygen	32.00								
Ammonia	17.03								
Hydrogen Sulfide	34.08								
Carbonyl Sulfide	60.08								
Sulfur Dioxide	64.06								
Water Vapor	18.02								
Hydrogen Chloride	36.46								
TOTAL GASES									
Gas Flow, Lb Moles/Hr									
Molecular Weight, Gases									
Gas Volume, ACFM									
Gas Volume, SCFM									
LIQUIDS:									
Water	18.02	100.00	64,889	100.00	64,889	100.00	30,944	100.00	30,944
SOLIDS:									
Carbon	12.01								
Hydrogen	1.01								
Oxygen	16.00								
Nitrogen	14.01								
Sulfur	32.06								
Chlorides	35.45								
Ash									
Moisture	18.02								
TOTAL SOLIDS									
SORBENT:									
CaO	56.08								
CaCO3	100.09								
CaS	72.14								
CaSO4	136.14								
MgO	40.31								
MgCO3	84.32								
Inerts									
TOTAL SORBENT									
TOTAL FLOW, Lb/Hr			64,889	64,889	30,944	30,944			
HEATING VALUE:									
Gas LHV, Btu/SCF									
Gaseous Fuel LHV, MMBtu/hr									
TEMPERATURE, F			230	366	230	366			
PRESSURE, PSIA			1.000	990	1.000	990			



HEAT AND MATERIAL BALANCE - BASE CASE  
SUFCO COAL WITH ZINC OXIDE BASED SORBENT

IDENTIFICATION	Molecular Weight	49		50 (Note 1)		51		52 (Note 1)	
		NOT USED		Net Steam From Product Gas Trim Cooler		Net Steam From Sulfator Steam Drum		Net Steam From Product Gas Cooler	
		Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr	Vol%	Lb/Hr
<b>GASES:</b>									
Carbon Monoxide	28.01								
Hydrogen	2.02								
Carbon Dioxide	44.01								
Methane	16.04								
Nitrogen	28.01								
Argon	39.95								
Oxygen	32.00								
Ammonia	17.03								
Hydrogen Sulfide	34.08								
Carbonyl Sulfide	60.08								
Sulfur Dioxide	64.06								
Water Vapor	18.02			100.00	0	100.00	34,246	100.00	93.8
Hydrogen Chloride	36.46								
<b>TOTAL GASES</b>				100.00	0	100	34,246	100.00	93.8
Gas Flow, Lb Moles/Hr					0.0		1,901.0		5,207
Molecular Weight, Gases					18.02		18.02		18.
Gas Volume, ACFM					0.0		357.1		978
Gas Volume, SCFM					0		12,020		32.9
<b>LIQUIDS:</b>									
Water	18.02								
<b>SOLIDS:</b>									
Carbon	12.01								
Hydrogen	1.01								
Oxygen	16.00								
Nitrogen	14.01								
Sulfur	32.06								
Chlorides	35.45								
Ash									
Moisture	18.02								
<b>TOTAL SOLIDS</b>									
<b>SORBENT:</b>									
CaO	56.08								
CaCO3	100.09								
CaS	72.14								
CaSO4	136.14								
MgO	40.31								
MgCO3	84.32								
Inerts									
<b>TOTAL SORBENT</b>									
<b>TOTAL FLOW, Lb/Hr</b>					0		34,246		93.8
<b>HEATING VALUE:</b>									
Gas LHV, Btu/SCF									
Gaseous Fuel LHV, MMbtu/hr									
<b>TEMPERATURE, F</b>					538		538		5
<b>PRESSURE, PSIA</b>					950		950		9

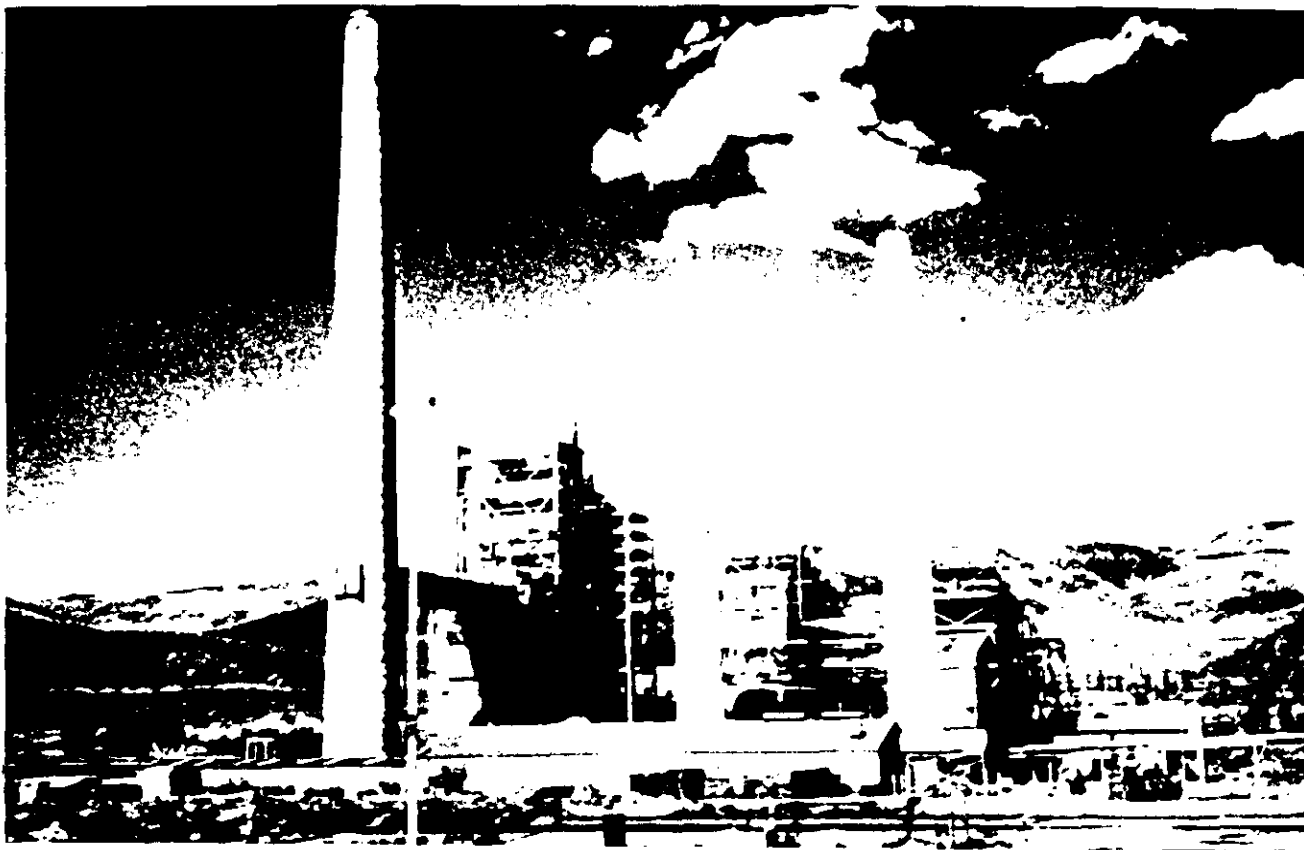
Note 1: This is total steam production from E-401 and E-403. Exact split is to be determined upon completion of all heat and material balance cases.

APPENDIX 5

PHOTOGRAPHS OF EXISTING TRACY FACILITY



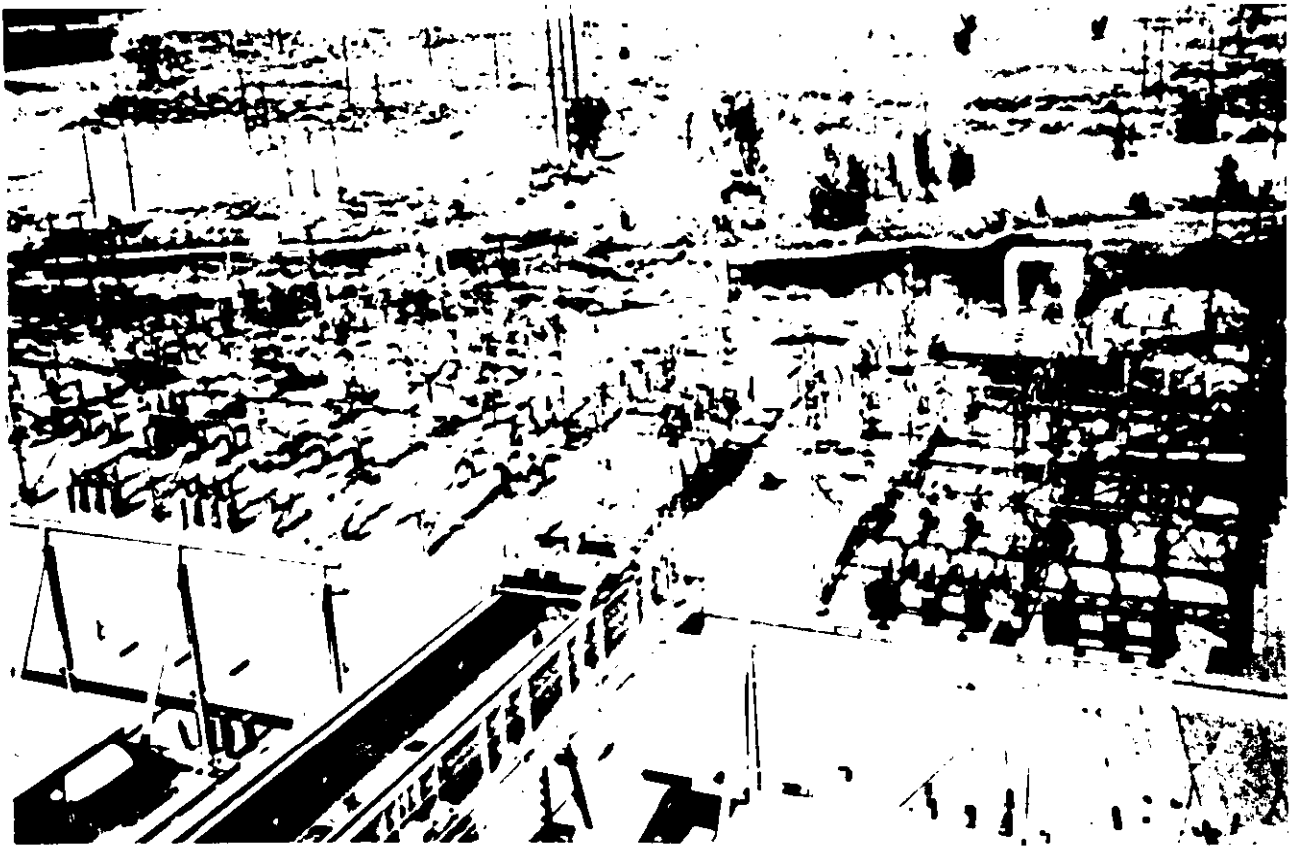
Aerial photograph of Tracy Power Station looking west with 120/345 KV switchyard in foreground.



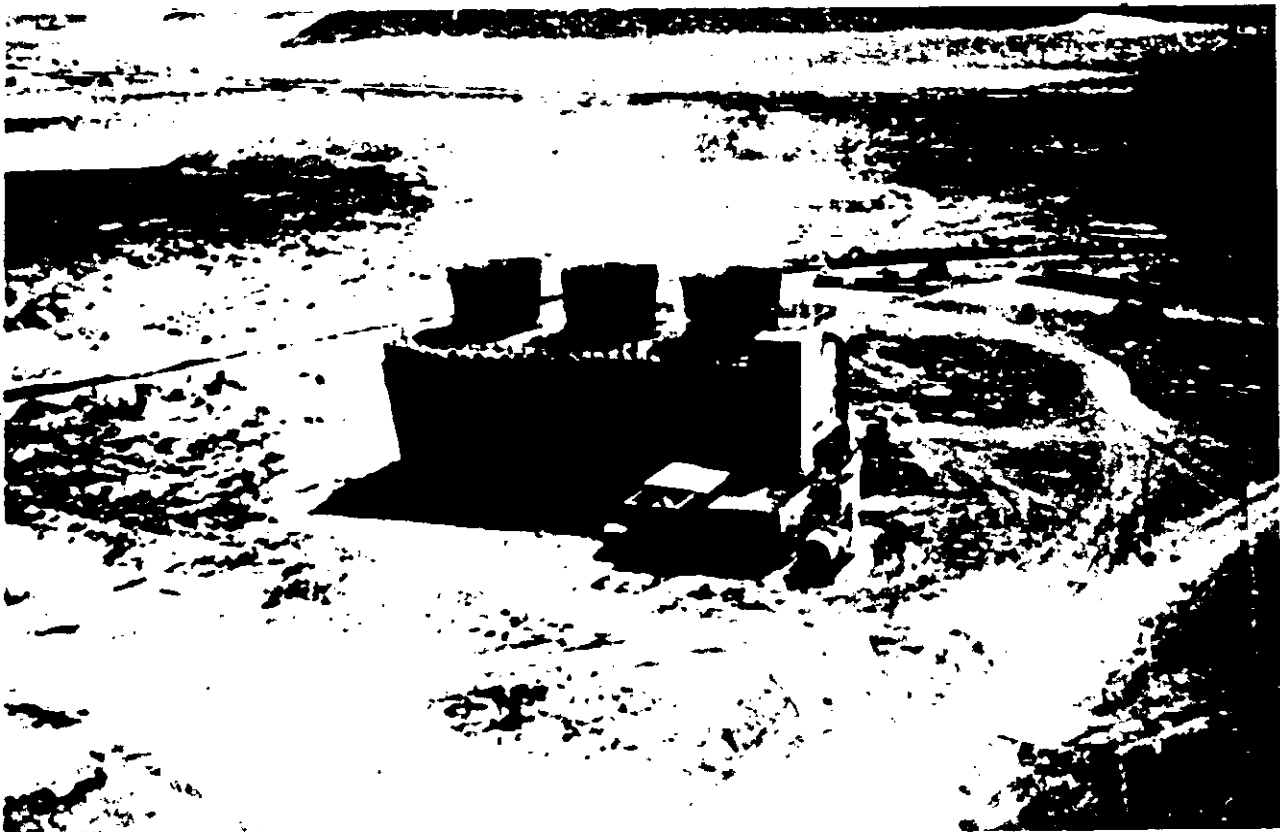
Existing Tracy steam electric generating Units No. 1 through No. 3 (from right to left). Photo looking North.



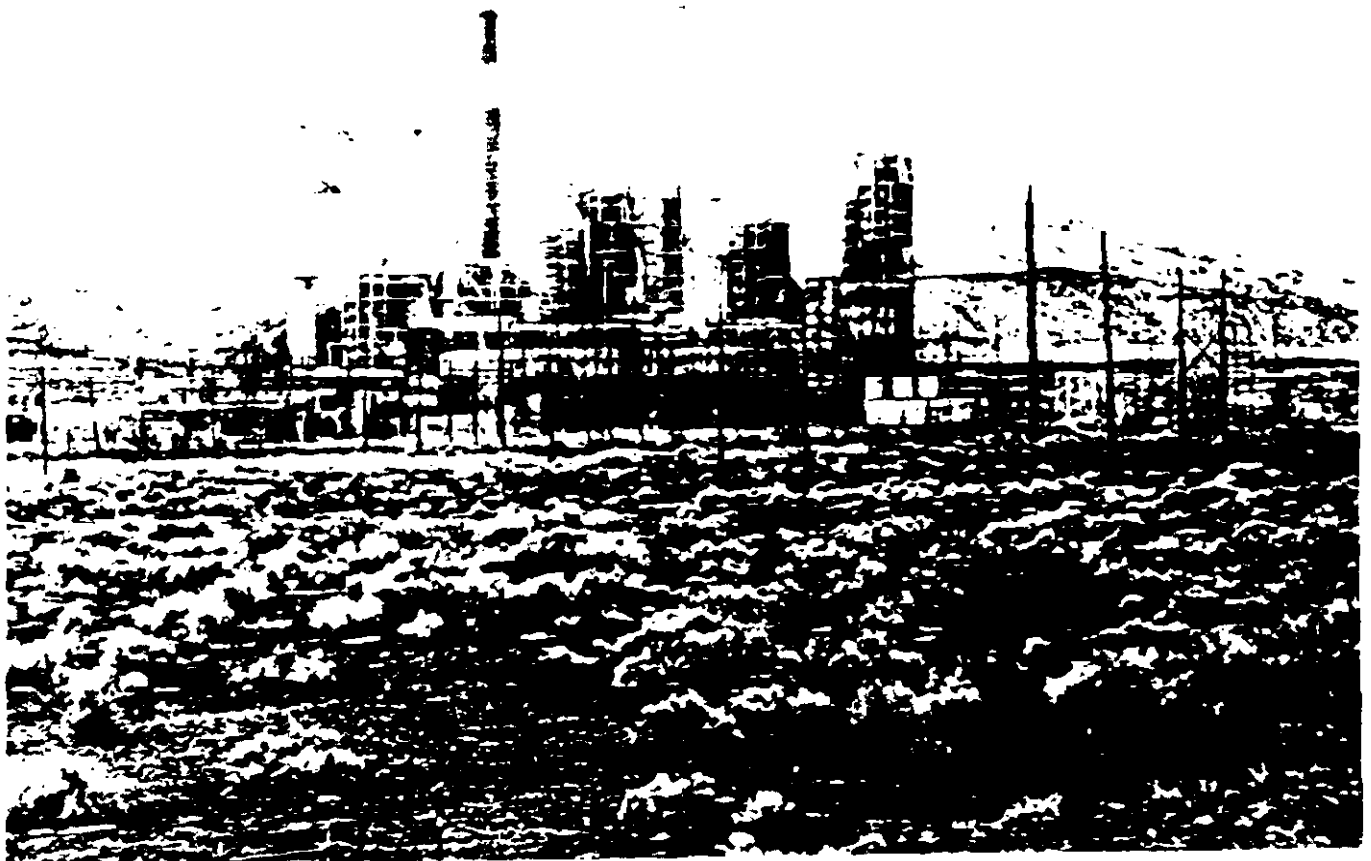
Existing steam electric units. Photo looking southeast across cooling pond for Tracy Units No. 1 & No. 2.



Existing 120 KV switchyard for Units No. 1 (right) through No. 3 (left).  
Photo looking north.



Cooling tower for Tracy Unit No. 3. Photo looking southwest from top of Unit  
No. 3.



Existing Tracy units (3 units on left) and proposed Pinon Project (right).  
Photo looking southwest.